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User Manual

Enhanced *mini*MACS

Doc-To-Help Standard Manual

Atlas Copco Assembly Systems

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*mini*MACS Enhanced / WinQCM-E

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Introduction

Overview

This manual describes the functionality of the enhanced *mini*MACS system. The system consists of the following physical or functional parts:

- The *mini*MACS PC
- Field Bus Unit, FBU
- QCM2/QCS2 Servo Drive Units

The *mini*MACS PC consists of three parts, the WinQCM-E GUI, the Station Controller and a MMS interface.

WinQCM-E is the tool used to configure the servos, including the tightening programs used. WinQCM-E is an enhanced version of the WinQCM-81.43.

The Station Controller is responsible for the co-ordination of the individual servos in order to make them act as a unit. It mainly handles start and stop of a cycle and possible reject management actions. In order to achieve real time performance the Station Controller is implemented using OpenControl. OpenControl provides a framework to program and run machine control applications on Windows NT system. See [Ref. 08] for a description of the OpenControl environment.

The MMS interface is used by other remote applications in order to access cycle data from the *mini*MACS PC. The MMS interface is implemented as a separate application, which is interfaced to the WinQCM-E using a socket.

The Field Bus Unit, or FBU, receives control data from the Station Controller over the Profibus interface. The FBU processes the control data and sends it to the servo drive units over the Lan1 bus. The status of the drive units is sent back the same way to the Station Controller. This communication chain is essential for the operation of the tightening system.

The QMC2 servo units performs the actual tightening. During the execution of a tightening cycle they records tightening information, i.e. torque and angle data. This data is stored in internal memory and can be retrieved by the WinQCM-E application over the Lan2 bus.

A miniMACS system may consist of up to 32 spindles.

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The rest of this manual describes the parts of a *mini*MACS system in more detail.

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The WinQCM-E

General

The WinQCM-E is mainly used for configuring the tightening program.

It displays result and status information from the tightening cycles, calculates SPC (Statistical Process Control) values, and retrives and displays traces recorded by the servos. To do so it interacts both with the servos and the Station Controller.

WinQCM-E also hosts the MMS interface.

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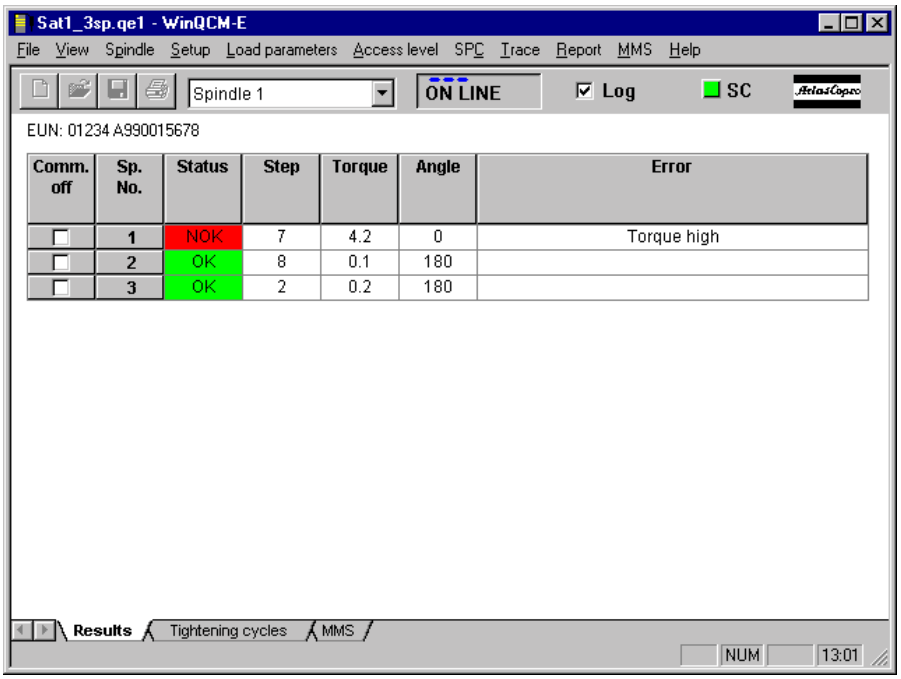
Windows

WinQCM-E has three windows, the **Result** window, the **Tightening cycles** window and the **MMS** window.

The Results Window

If the program is in on-line mode and you switch to the result window results are continuously collected from all spindles in the system and viewed on the screen.



The results (step, torque values, angle values and error messages) are shown in one line for each spindle. If the status is OK the status box is green and if it's NOK the status box is red and a text string explain type of fault. If the spindle is running the box is white and the status is RUNNING.

By clicking in the **Comm.Off** box, the selected spindle will be ignored in the CAN communication. This is useful e.g. when one of servos is defect.

The step, torque and angle values presented originate from the step marked in the **Tightening cycles** table, see Tightening steps.

Tightening cycles Window

Using the tightening cycles window you can display and edit the tightening program.

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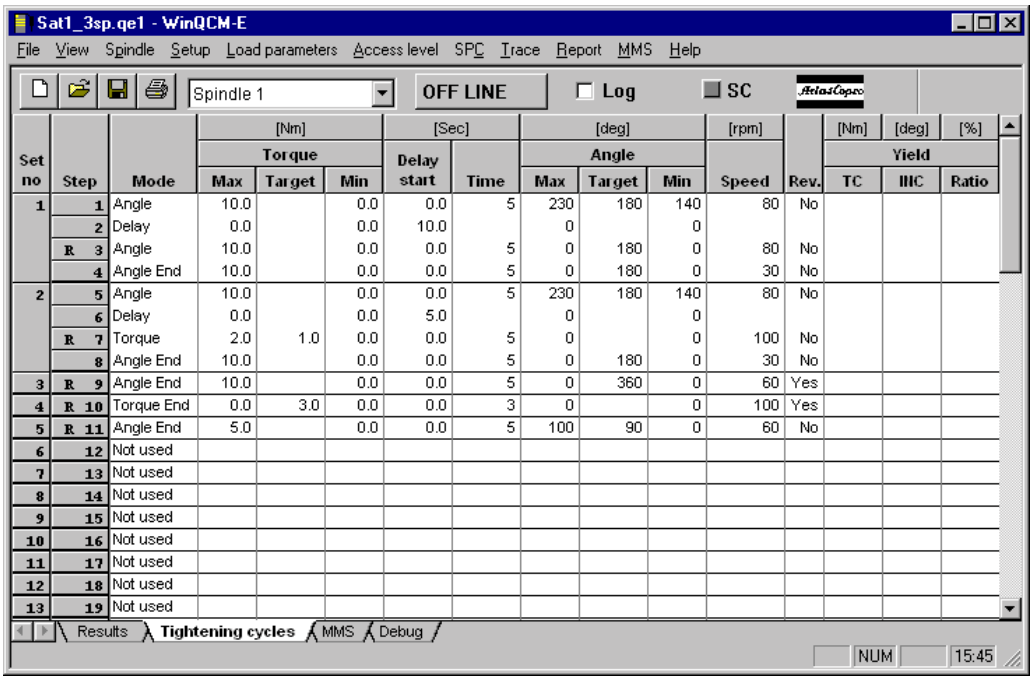

Set no	Step	Mode	[Nm] Torque Max	[Nm] Torque Target	[Nm] Torque Min	[Sec] Delay start	[Sec] Time	[deg] Angle Max	[deg] Angle Target	[deg] Angle Min	[rpm] Speed	Rev.	[Nm] Yield TC	[deg] Yield IIC	[%] Yield Ratio
1	1	Angle	10.0		0.0	0.0	5	230	180	140	80	No			
	2	Delay	0.0		0.0	10.0		0		0					
	R 3	Angle	10.0		0.0	0.0	5	0	180	0	80	No			
	4	Angle End	10.0		0.0	0.0	5	0	180	0	30	No			
2	5	Angle	10.0		0.0	0.0	5	230	180	140	80	No			
	6	Delay	0.0		0.0	5.0		0		0					
	R 7	Torque	2.0	1.0	0.0	0.0	5	0		0	100	No			
	8	Angle End	10.0		0.0	0.0	5	0	180	0	30	No			
3	R 9	Angle End	10.0		0.0	0.0	5	0	360	0	60	Yes			
4	R 10	Torque End	0.0	3.0	0.0	0.0	3	0		0	100	Yes			
5	R 11	Angle End	5.0		0.0	0.0	5	100	90	0	60	No			
6	12	Not used													
7	13	Not used													
8	14	Not used													
9	15	Not used													
10	16	Not used													
11	17	Not used													
12	18	Not used													
13	19	Not used													

A step is selected by clicking on it. To change the parameters of a step double click on the step in question. This will launch the Tightening steps dialogue to be opened in which you can do your modifications.

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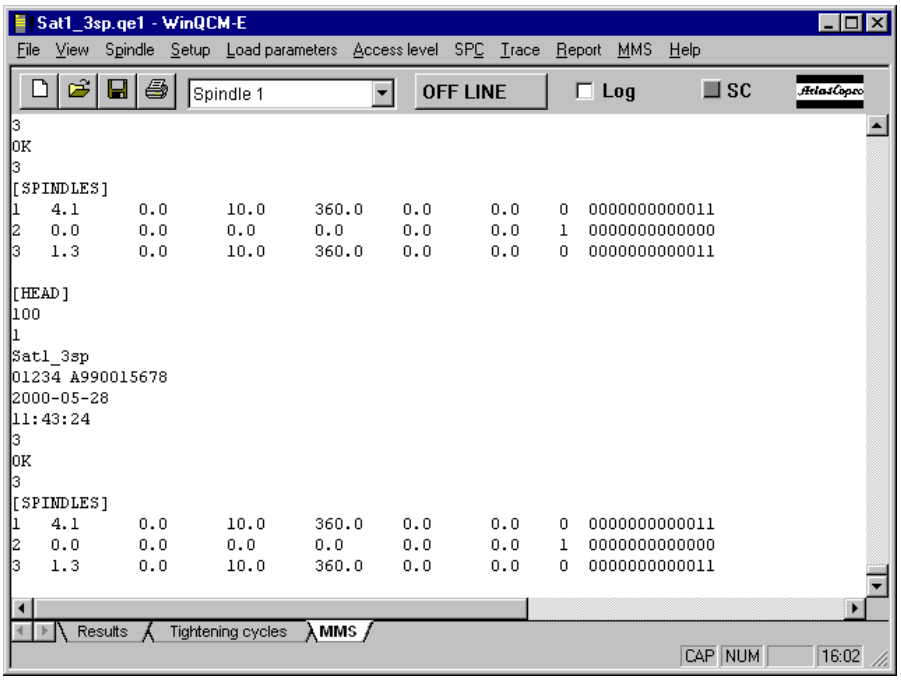
The MMS Window

Using the MMS window you can study the current status of the MMS queue. The MMS queue contains the result of the last cycles executed. The length of the queue is default 100 cycles but is configurable. See The MMS Interface for a description of the MMS queue and how the cycle data displayed is formatted.



There are two options for which cycle data that can be displayed in this window:

- All cycles currently recorded in the MMS queue
- All cycles currently recorded in the MMS queue that have not been read yet by the MMS server.

The data currently displayed can either be printed or saved to disk by using the menu alternative **File/Print** or **MMS/Save**.

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Menus

This section lists describes the functions that are available from the WinQCM-E menu.

File

Here you will find the standard functions for file handling: New, Open, Save, Save as, Print, and open any of last four files.

New

Use this function to create and initiate a new set-up. When selected the System dialogue is displayed in which you must enter the main system parameters.

Open

Opens an existing WinQCM-E set-up file. This function is only available when the system is in OFF LINE mode.

Print

If the currently displayed window is the Tightening cycles window then the current set-up is printed. The print out will list all parameters for each spindle included, one spindle per page.

If the currently displayed window is the MMS window then current contents of the window will be printed. It's possible to print all pages, from page to page or current page.

Exit

Ends the program. If the current set-up is modified you will be asked if you want to save the file.

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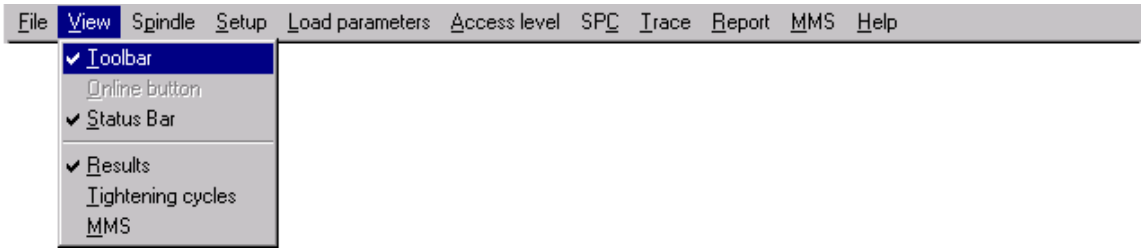
View



Using this menu you can customise the layout of the GUI, i.e. which windows, toolbars, etc.that should be displayed.

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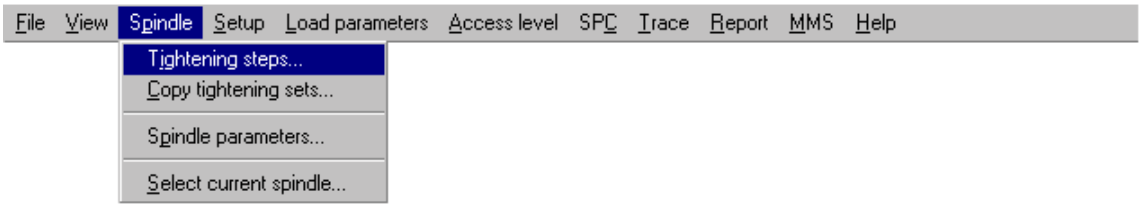
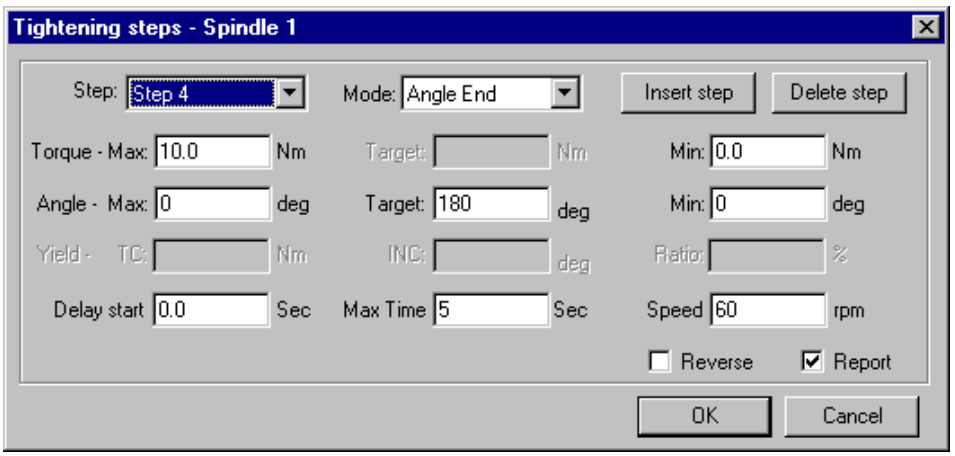
Spindle


File View Spindle Setup Load parameters Access level SPC Trace Report MMS Help
Tightening steps...
Copy tightening sets...
Spindle parameters...
Select current spindle...

Tightening steps

Displays the Tightening step dialogue in which you can set the parameters of a step.



Each tightening cycle is built up of different control modes, such as torque, angle, jog etc. **Mode** can be selected from one of the following step types: Torque, Angle, Delay, DynaTork, Delay End, Angle End, Jog End, Torque End or Yield.

To determine the last step of a set, the control mode in that step should be of “End type”. Such steps are displayed with a horizontal line under the step to indicate the end of a tightening set.

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Available Control Modes are given by the following table:

Control Mode	Description
Delay	Continue with the next step after the “Delay Time”. If the previous step was a Dyna-Torque step, keep the nutrunner current constant until the “Delay Time” is reached. If the angle ended below “Min Angle” or at any time exceeded “Max Angle”, then interrupt the cycle and set status NOK.
Torque	Wait for “Delay Start” then run with the “Speed” value until pre-set “Target” is reached. If the angle ended below “Min Angle” or at any time exceeded “Max Angle”, or if “Max Time” was reached before pre-set “Torque”, then interrupt the cycle and set status NOK.
Angle	Wait for “Delay Start” then run with the “Speed” value until pre-set “Target” is reached. If the torque at any time exceeded “Max Torque”, or if “Max Time” was reached before pre-set “Angle”, then interrupt the cycle and set status NOK.
Jog	Wait for “Delay Start” then run with the “Speed” value as long as the Start input signal is logic one. If the angle ended below “Min Angle” or at any time exceeded “Max Angle” or “Max Torque”, or if “Max Time” was reached before the Start command was released, then interrupt the cycle and set status NOK.
DynaTork	Wait for “Delay Start” then run with the “Speed” value until pre-set “Target” is reached. Then continue to the next step, which is always a Delay step (see above). If, during the DynaTork step, the angle ended below “Min Angle” or at any time exceeded “Max Angle”, or if “Max Time” was reached before pre-set “Torque”, then interrupt the cycle and set status NOK.
Yield	Wait for “Delay Start” then run with the “Speed” value until measured torque slope is less than a pre-set “Torque slope” percentage (Ratio) of the torque slope reference. Torque slope is measured continuously over a pre-set “Angle INC”. Torque slope reference is stored when “Torque Ref” (TC) is reached. If the angle ended below “Min Angle” or at any time exceeded “Max Angle” or “Max Torque”, or if “Max Time” was reached before pre-set “Torque Slope”, then interrupt the cycle and set status NOK.

Depending of the selected mode the editable parameters change according to below:

Mode	Delay start	Max torque	Target torque	Min torque	Time	Max angle	Target angle	Min angle	Speed
Delay End	No	Yes	No	Yes	Yes	Yes	No	Yes	No
Torque End	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Angle End	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Jog End	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Delay	No	Yes	No	Yes	Yes	Yes	No	Yes	No
Torque	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Angle	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
DynaTork	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Yield	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes

The parameters TC, INC and Ratio are only editable if the control mode is Yield.

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Angles are programmed in degrees.

Max. time is programmed in seconds. Time for Delay and Delay End steps can be programmed with one decimal.

Speed is programmed in rpm. In all steps except Delay and Delay End one can select to run in **Reverse** direction.

Torque is programmed in Nm or fl.lb. Torque values are **always** programmed with one decimal.

Max. allowed torque is set-up in the Spindle parameters menu.

When a step is **Deleted** the step is removed and the steps following are moved up one row. As step no 64 a new , empty, step is added.

When a step is **Inserted** the currently selected step, and the steps following, will be moved down one row. The step added will be an empty step.

When a **DynaTork** step is programmed, a dialog appears where a Delay or Delay End step can be selected. The Delay/Delay End step is automatically inserted after the DynaTork step.

Max. and Min. Torque and Angle limits can **be programmed to 0 meaning that the parameter is not used.**

A click in the **Report** box means that the Torque and Angle result will be reported from this step. A report step is indicated with an **R** before the step number in the Tightening cycles Window table.

Note: One step in a set must be marked for reporting.

If a tightening ends NOK for a spindle, the reported data comes from the step that was NOK.

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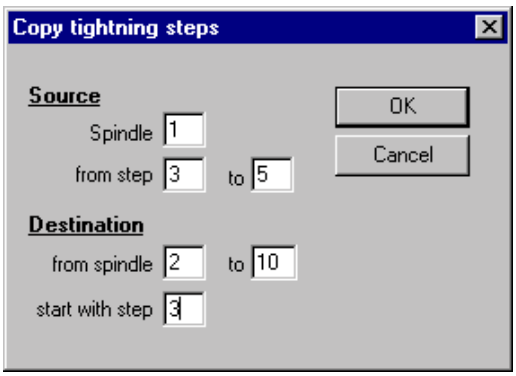
Copy tightening steps

This function is used to copy tightening steps from one spindle to other spindles.



You select where you want to copy from - Source - and where you want to copy to - Destination.

In the example above step 3, 4 and 5 are copied from spindle 1 to spindle 2 - 10.

Note: The report setting is only copied correctly if all 64 steps of a spindle are copied at the same time. The default values in the dialog will copy all 64 steps.

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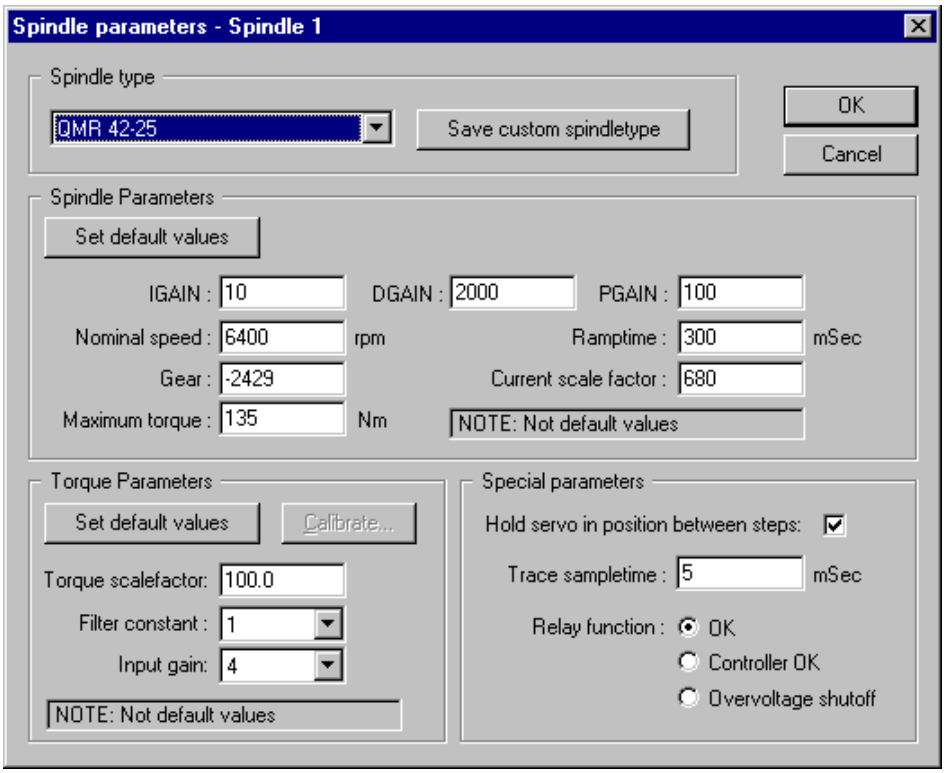
Spindle parameters

Displays the Spindle parameter dialogue in which you configure the all of the spindle parameters for a spindle. This includes spindle parameters, torque parameters and special parameters.



It's possible to add custom spindletypes. To do this, first assign values to the "Spindle Parameters" and/or "Torque Parameters". Then click the button "Save custom spindletype". This will bring up a dialog where a name are assigned to the custom spindletype.

To edit an existing custom spindletype; first select the custom spindletype from the combo and click "Set default values" for Spindle Parameters and/or Torque Parameters. Then edit the vaules of the Parameters. Then click "Save custom spindletype" and select the existing custom spindletype from the list. The custom spindletype will be overwritten with the new values.

The saved spindletype will appear in the combo. The custom spindletypes are saved in a special file in the same directory as the WinQCM.exe file. If this file is moved to another computer with WinQCM, the custom spindletypes can be used there too.

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Spindle Parameters

Select a spindle type and press the ”Set default values” button. Default parameters will then be automatically inserted.

If the read values of the parameters doesn’t correspond with the default values of the selected spindletype, the label “NOTE: Not default values” are displayed.

With the Maximum torque parameter the range for the spindle is selected.

Note: The default value of ”Maximum torque” is not stored in the servo meaning that if you read parameters from the servo, WinQCM will present the default value of the selected spindletype, which may differ from the manually edited value.

Depending on the spindle type the default values of the parameters are as follows:

SpindleQMR	PGAIN	IGAIN	DGAIN	Nom. speed	Cur. scale See note 1	Gear See note 2	Max torque
42-16	100	10	2000	7000	220	-1600	27
42-25	100	10	2000	7000	220	-2578	44
55-15	100	10	2000	6400	680	-1577	90
55-24	100	10	2000	6400	680	-2429	135
62-32	100	10	2000	6400	680	-3208	190
62-46	100	10	2000	6400	680	-4654	275
90-30	125	5	2500	5000	1900	-3033	560
90-47	125	5	2500	5000	1900	-4684	880

Note 1: The current scale factor is calculated as K_{Tmotor} * $I_{MaxServo}$ * 100.

Note 2: For spindles where the motor has opposite rotation direction from the socket holder (u-gear or 2-wheel offset), the values shall be multiplied with –1 (minus one).

Torque reading

This function is used to configure the torque transducer. It is only valid for servos of QCM/S 2-T type .

Select a torque transducer and press the “Set default values” button. Default parameters will then be automatically inserted.

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If the read values of the parameters doesn't correspond with the default values of the selected spindletype, the label "NOTE: Not default values" are displayed.

The **Filter constant** and the **Input gain** can be edited manually if you e.g. have another type of torque transducer. The **Torque scale factor**, can either be edited manually or calculated automatically by the **Calibrate...** function. The **Calibrate...** button is only enabled while online.

Default values for Torque scale dependent on transducer type are:

Torque transducer	**20 Nm**	**50 Nm**	**100 Nm**	**200 Nm**	**1000 Nm**
Default value	20.0	50.0	100.0	200.0	1000

Default value for the Filter constant is 1. Available filter settings are 0, 1, 2 and 3 where 0 gives the hardest filtering.

Default value for Input gain is 4. Available gain settings are 1, 2, 4, 8 and 16. With gain 4 at least 100% of the transducer range can be used. Increased gain results in that the usable transducer range is decreased and the resolution of the signal is increased.

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If you press the **Calibration...** button the **Torque Calibration** form is displayed.

The **Start Measuring** button is enabled when there are at least one **Spindle Torque** field that is empty and a measuring is not started.

Press the **Start Measuring** button to start the measuring. This will cause WinQCM to extract the torque value, for the spindle in question, from the cycle data packages received from the spindles. The torque value is automatically written in the next free **Spindle Torque** field of the form.

The measuring continues until all **Spindle Torque** fields are filled with a value or that the button **Stop Measuring** is pressed.

For each value read from the spindle the corresponding torque values from the calibration equipment should be entered in the **Monitored Torque** field next to the **Spindle Torque** field. This can be done during, or after the measurements.

Pressing the **Clear** button for a result clears the entered values (both the **Spindle Torque** and **Monitored Torque**). This is done e.g. when one or more torque readings are found erroneous and can be done while measuring is on going.

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When all **Spindle Torque** and **Monitored Torque** fields have values the **Calculate** button is enabled. Pressing causes a new value of the Torque Scalefactor to be calculated using the following formula:

$$\text{New value} = \frac{\text{Current value}}{(TS - TM)/\ TS + 1}$$

where

TS = Average of the five (5) values entered in the "Spindle Torque" fields.

TM = Average of the five (5) values entered in the "Monitored Torque" fields.

The new value calculated is automatically written in the corresponding field.

Press **OK** to close the form and return to the **Torque reading** form. The field **Torque scalefactor** in the latter form is now updated with the calculated value. Press **OK** in this form to actually update the set-up and download the new value to the servo.

Special

Check **Hold servo in position between steps** if you want the servo to control this for you.

Using the **Relay function** radio buttons you define which event that should activate the relay output.

With **Trace Sample Time** you control the sample time with which traces are recorded. Since a trace consists of up to 2000 samples a sample time of five ms makes it possible to record traces up to 10 seconds. If the cycle is longer than the maximum trace time the older values are truncated.

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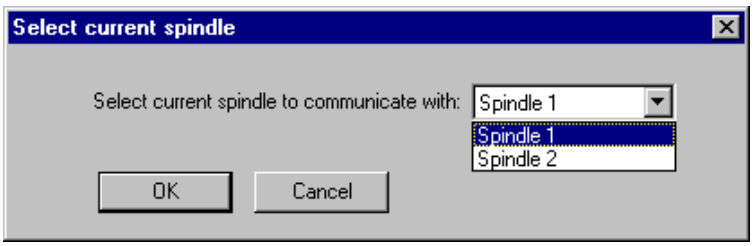
Select current spindle

Invokes the following dialogue:



Here you select the current spindle. Available spindles depends on the number of spindles that was set using the System dialogue.

This function is also available on the toolbar.

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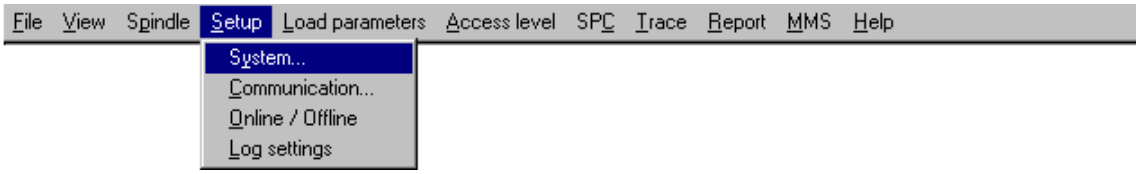
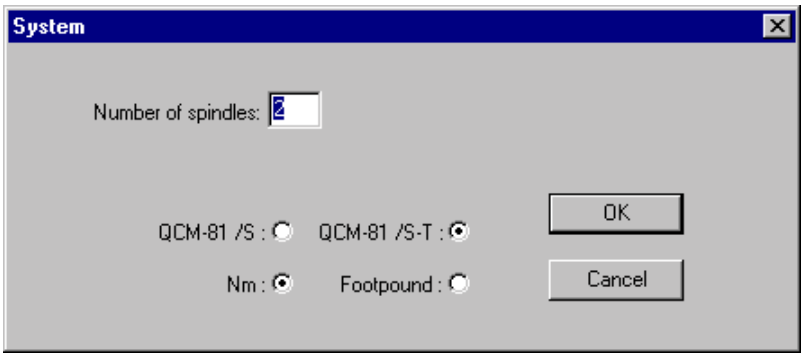
Setup


File View Spindle Setup Load parameters Access level SPC Trace Report MMS Help
System...
Communication...
Online / Offline
Log settings

System

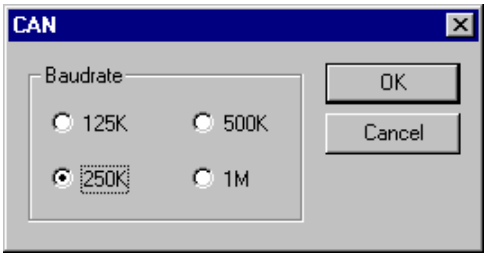
This function is used to set the main parameters of a system.



Here you can set how many spindles there are in the system, the type of servos used, and the torque unit.

Communication

Displays the parameters of the CAN communication.



You are able to set the baud rate of the CAN board in the PC. If you change the baud rate here you must ensure that the corresponding parameters are set in all servos as well.

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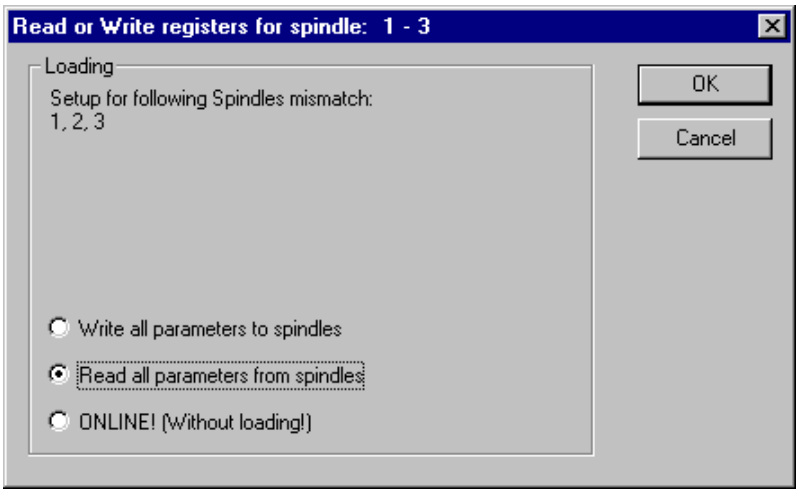
On-line / Off-line

Using this function you control the communication state of WinQCM-E.

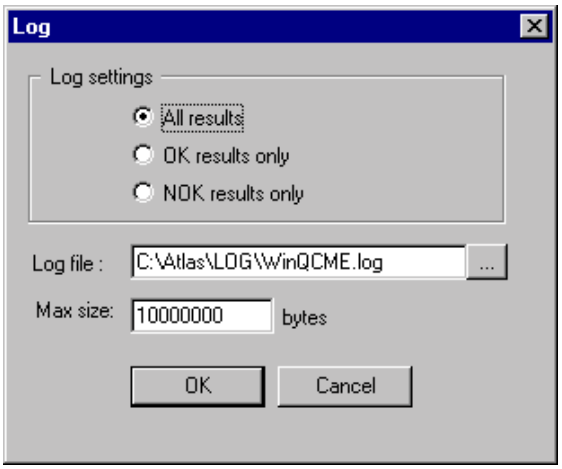
If the program is in **Online**-mode, it will be changed to **Off-line**.

If the program is in **Off-line**-mode it will be changed to **Online**. When going online you will be asked whether to **Write all parameters** to the spindles or **Read all parameters** from the spindles or just go **ONLINE! (Without loading)** . Before the dialog is shown, the spindles are passed by to check if set-up is up-to-date. If there are any mismatch you will be notified. Select Write or Read if set-up mismatch, otherwise select **Online** and click **OK**. If you choose **Cancel** the program will be in **Off-line**-mode. See also Load parameters.



Log Settings

Opens a dialogue in which you can configure how logging should be performed, if enabled.



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Select which cycles you want to log using the **Log Settings** radio buttons

- **OK results only** means that all, not inhibited, spindles must be OK for the cycle to be logged.
- **NOK results only** means that if one, not inhibited, spindle is NOK then the cycle is logged.

Specify the location of the log file (file name and directory) using field labelled **Log file** and the size of it using the **Max size** field.

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Load parameters

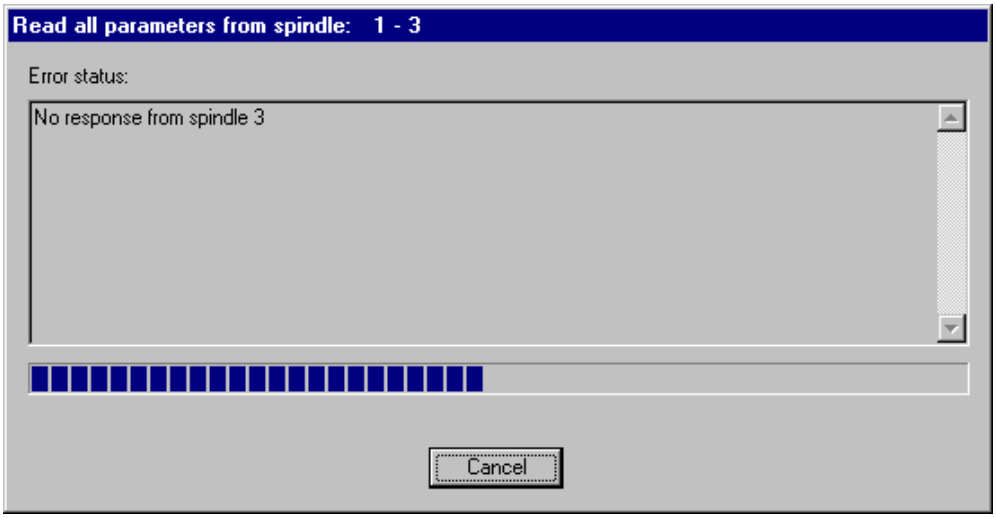
File View Spindle Setup Load parameters Access level SPC Trace Report MMS Help
Write all parameters to spindles
Read all parameters from spindles

Write all parameters to spindles

Write all programmable parameters to the servos. If the program is in off-line mode it will automatically be set in on-line mode after this operation

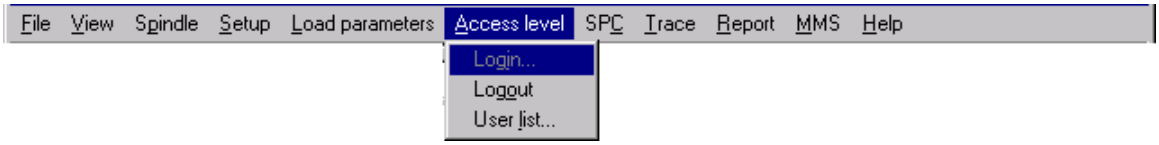
Read all parameters from spindles

Read all programmable parameters from the servos. If the program is in off-line mode it will automatically be set in on-line mode after this operation.



You can click **Cancel** during loading and the dialog will close. The program will still be in on-line mode. The read parameters will not be updated in the program. All written parameters though will remain in servo.

Access level



The program has two different access levels. The access level 3 is the highest with the right to modify everything. In the user list you can add new users with an access level.

In the user list you also select a default access level. This is the access level the program has when you start it. If you select access level 3 as default access

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level, the user doesn't need to login since the user automatically has the right to do everything.

When no user is logged in access level 1 is selected. Access level 1 has the right to look at everything but not to change anything. This access level has the following rights and restrictions:

1. Not allowed to open setups from file.
2. Allowed to go online and read a set-up from the servo.
3. Not allowed to go offline. This also prevents the user from exiting the application. When WinQCM is offline, the user is allowed to exit.

It's possible to change logged in user while WinQCM is running. If a access level 1 user is online it's not possible to exit. By logging in as a user with access level 3 it's possible to exit WinQCM.

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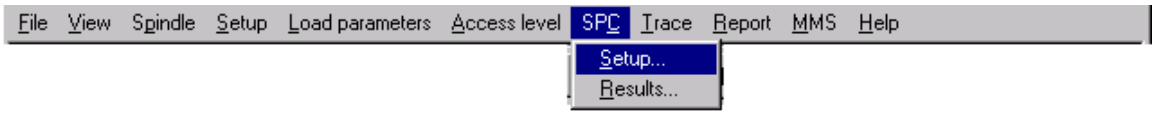
SPC



The built-in SPC (Statistical Process Control) is very flexible and makes it possible to tailor data collection and calculations to suit most needs.

Data Collection for SPC

Data for SPC is collected for all spindle cycles with OK status. Data are collected only for those variables that have been set up using the SPC Set up function. Data are collected in two main ways:

- as subgroups
- as latest results

When data are collected into subgroups, data from a specified number of samples are used to calculate Average and Range or Standard deviation, which are saved for the subgroup. The original values are automatically deleted.

This is repeated with a selectable frequency, either specified in number of samples, or in time between start of subgroups.

If frequency is specified in time, a subgroup is discarded if it is not complete within 30 minutes.

For a detailed view of the latest samples there is also a buffer for latest results. This contains all the latest samples, but for a much shorter period of time.

Which variables to collect are set up uniquely for each spindle and set.

The data currently collected and held by the SPC module is saved to disk whenever it is updated.

See Appendix 1: SPC Calculations for a description on how the SPC data is calculated.

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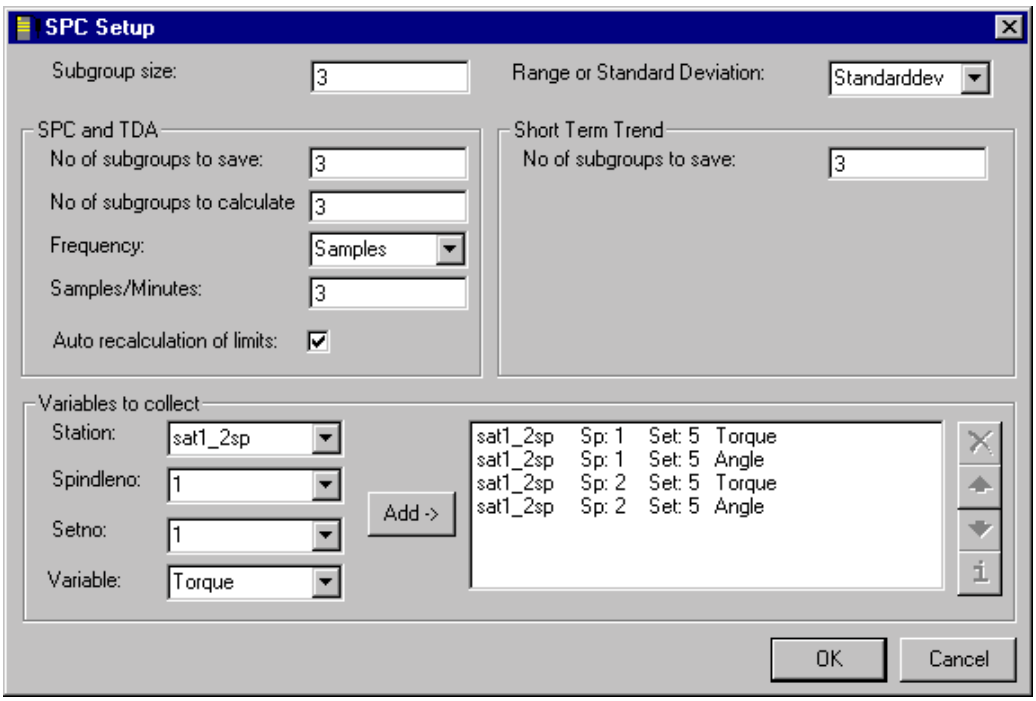
Set up…

Use this alternative to define how calculation should be performed and which variables to collect.



Specify **Subgroup size** and if you want to use **Range** or **Standard Deviation**.

In the **SPC and TDA** frame, set up values for normal SPC. Do the same for the **Short Term Trend** frame. These values will be used for calculations on all spindles, and sets.

In the **Variables to collect** frame, add those variables you want to check. Select **Spindle**, **Set**, and **Variable**. For **Spindle** you could specify **All**. Press **Add**. The variable shows up in the list box.

To take away a variable from the list, select it and press the remove button . If you want to rearrange the order, select an item and press the up or down buttons to move it upwards or downwards in the list.

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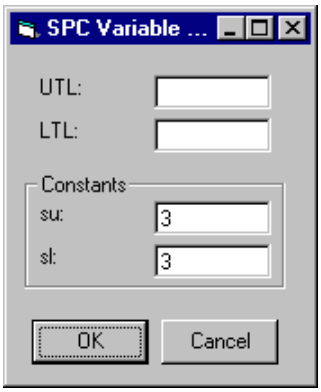

If you press the Information button i a dialogue box is presented where you can enter the *UTL*, *LTL*, *su* and *sl* values for the selected variable.

Results…

The menu alternative **SPC/Result** invokes the View Statistics window, which displays the statistical curves calculated by the SPC. In the upper right corner you select which type of display you want:

- Average and Standard Deviation/Range curves
- Ditto for Short Term Trend
- Histogram

Select the variable you want to study with the controls **Spindle**, **Set**, and **Variable**. When a selection is made, the curves for Average and Standard deviation, or Range,

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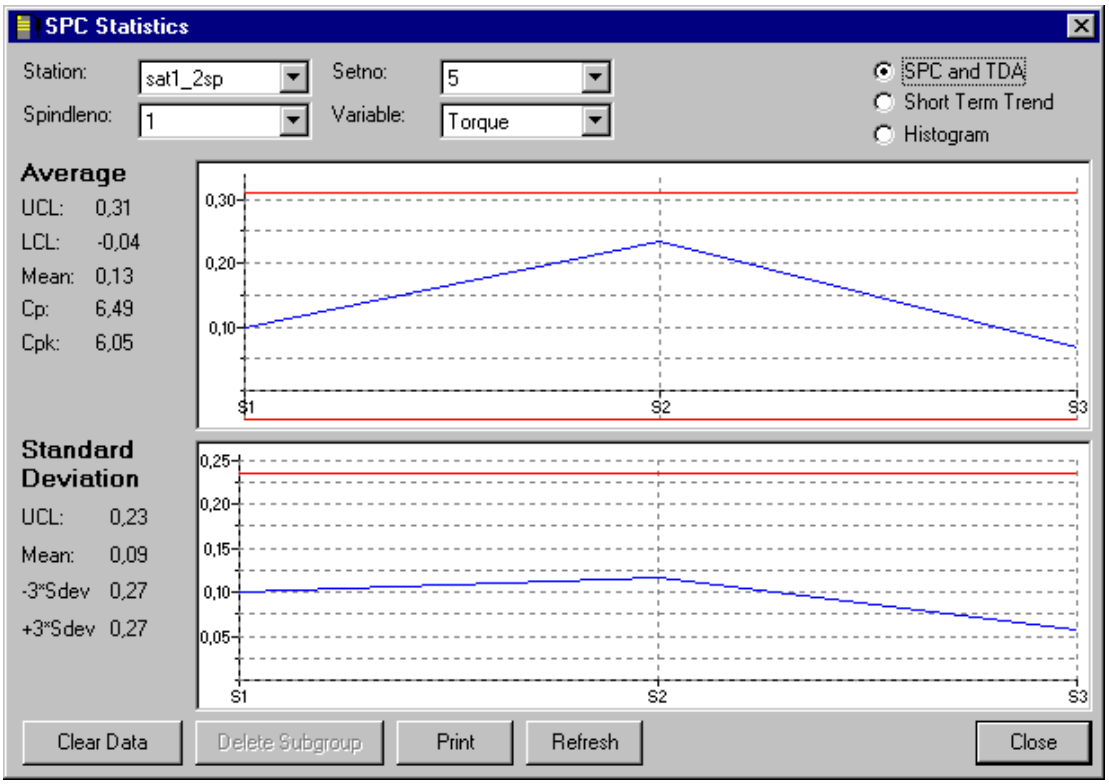

are plotted for the variable in question. To the left the current values of e.g. Cp and Cpk are displayed. These values are either calculated on the SPC and TDA data buffer or the short term trend buffer dependent on the current selection in the form.

If you find a subgroup in the SPC and TDA buffer, which have an abnormal value, you can delete it. Click in the diagram on the subgroup you want to delete and press **Delete Subgroup**.

To reset the values of the SPC buffers, and all values calculated, for all variables do press the button **Clear Data**. To update the window, press the button **Refresh**.

If you select Histogram you will get a different view. The histogram is automatically scaled so there is 25% of the screen left of *LTL*, and 25% right of *UTL*. The limits are shown. The full screen is divided into 20 classes.

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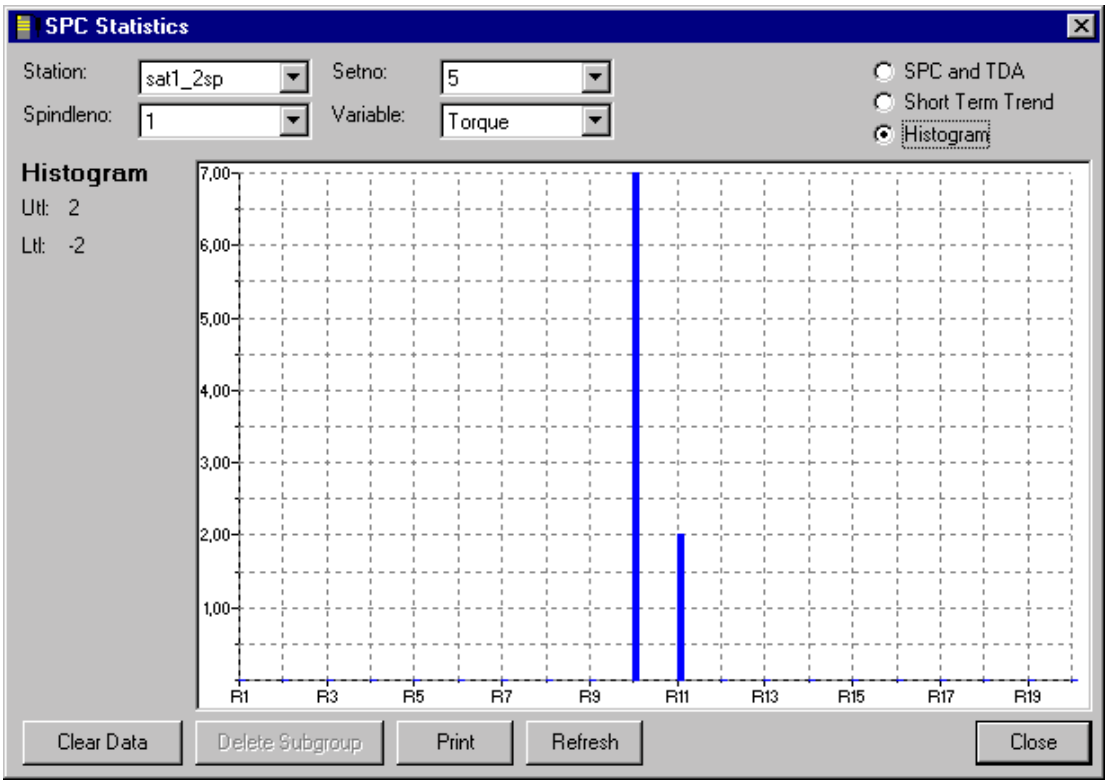

No matter whether you display SPC and TDA, Short Term Trend or Histogram you may study a particular part of the curve by zooming it in. Place the mouse cursor on the left most position that is of interest, press the left mouse button and drag the cursor to the right until the wanted area is marked and release the left mouse button. Click on the right mouse button zoom out again.

If you want to have the current view on paper, press the button **Print**.

Trace

Each servo records the current torque and angle values during the tightening cycle. This trace is stored in the servo. Each servo stores the traces of the10 last cycles as well as the 10 last NOK cycles. Here a cycle is found to be OK/NOK based only on the result of each individual servo, i.e. spindle OK/NOK.

The menu alternative **Trace/View Traces…** invokes the Trace viewing window, which is used to present the traces.

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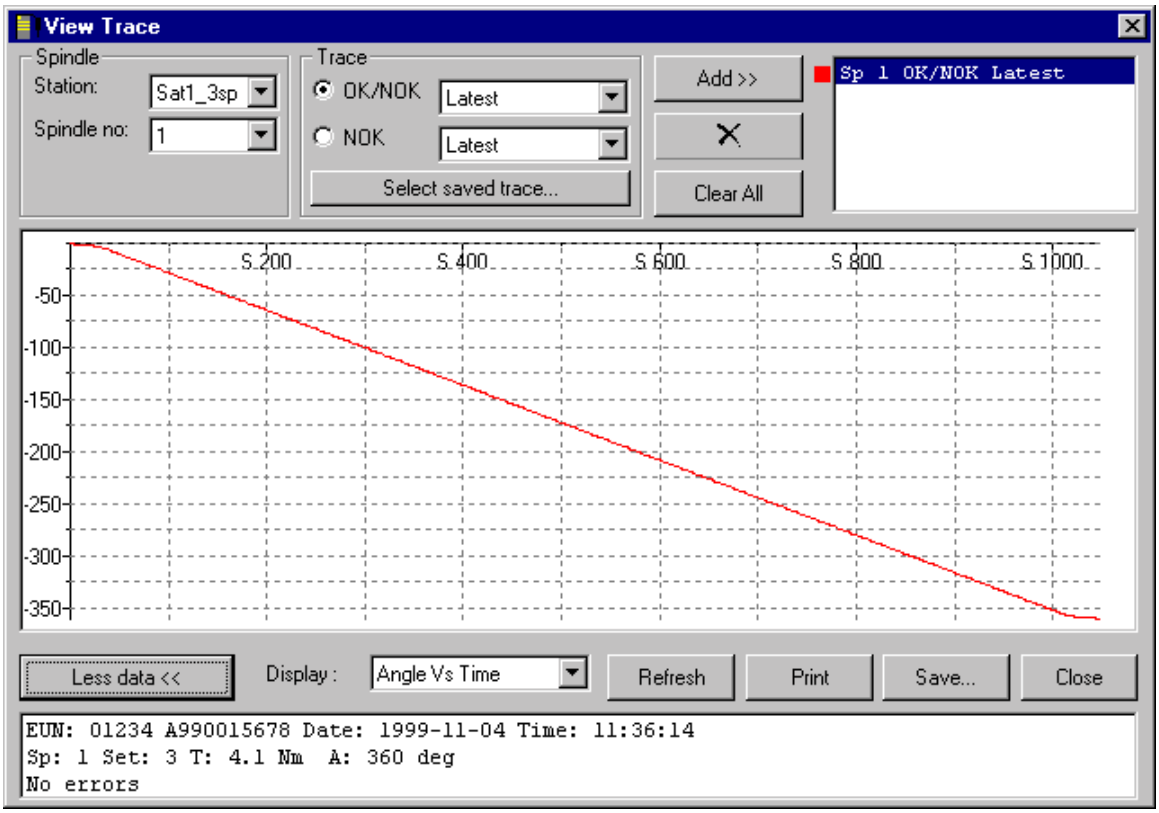

Select the spindle you are interested in by use of the **Spindle** fields. Then use the **Trace** fields to select which of the traces stored for that spindle to fetch. Finally, press the button **Add** to display the trace. You can also add earlier saved traces using the **Select saved trace…** button, see below. Up to six traces may be displayed as the same time.

When a trace is added, all traces already displayed will be kept as well. To remove one or more traces mark them in the list of currently displayed traces (in the upper right corner of the window) and press the button ✕. To remove all traces, press **Clear All**.

If you press the **More Data >>** button the lower part of the window is unfolded and displays cycle data corresponding to the trace shown. If more than one trace is displayed this field is cleared.

If several traces are displayed the x-axis is scaled for the trace that is marked in the list of displayed traces. The different curves are identified by different colors.

If you want to study a particular part of the trace you may zoom it in. Place the mouse cursor on the left most position that is of interest, press the left mouse button and drag the cursor to the right until the wanted area is marked and

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release the left mouse button. Click on the right mouse button zoom out again.

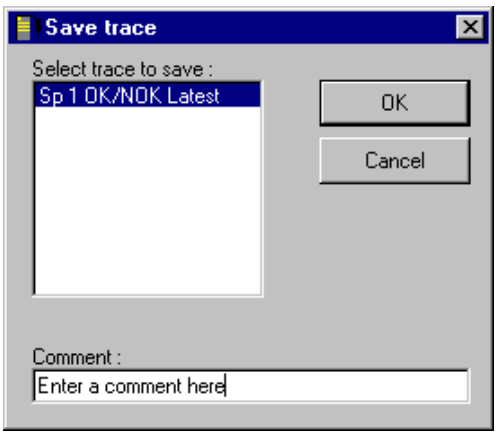
Select in which form you want to present the trace with the **Display** control. The following choices exists:

- Torque Vs Angle
- Torque Vs Time
- Angle Vs Time

Press the **Refresh** button to re-read and re-display all traces currently selected. Note that this may cause completely new traces to be displayed since which trace to up-load from a spindle is pointed out relatively to the most recently recorded.

Press the **Print** button to print the trace currently viewed.

If you see a trace that is interesting in some respect and therefore want to store it on disk, press the **Save** button. You will then be presented a form where you may enter an optional comment that will be stored together with the trace.



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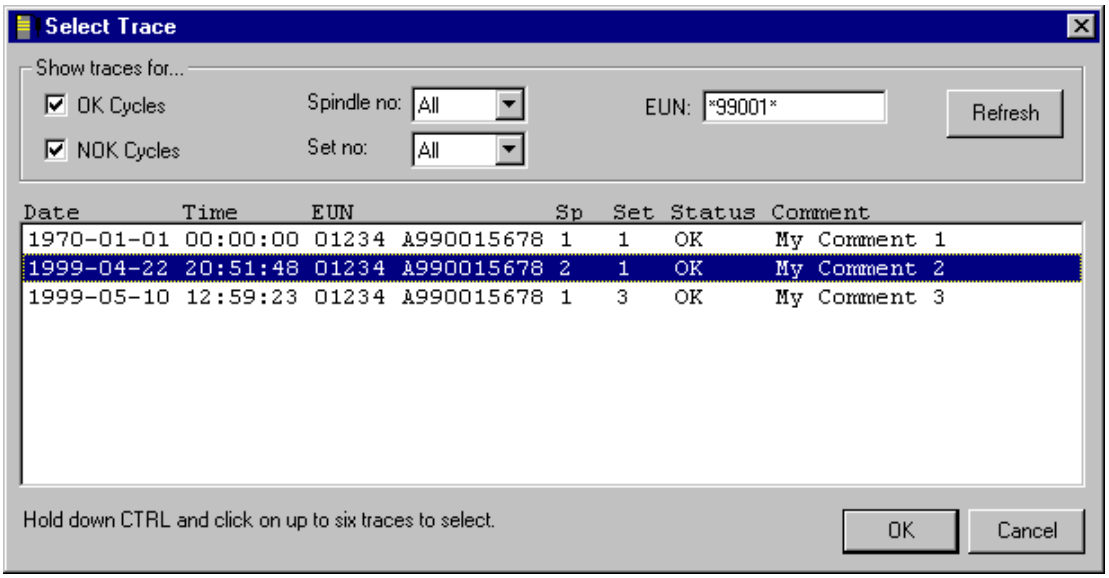
Saved traces can be displayed with use of the **Select…** button. When pressed the following form is displayed:


Select Trace
Show traces for...
OK Cycles
NOK Cycles
Spindle no: All
Set no: All
EUN: *99001*
Refresh
Date Time EUN Sp Set Status Comment
1970-01-01 00:00:00 01234 A990015678 1 1 OK My Comment 1
1999-04-22 20:51:48 01234 A990015678 2 1 OK My Comment 2
1999-05-10 12:59:23 01234 A990015678 1 3 OK My Comment 3
Hold down CTRL and click on up to six traces to select.
OK
Cancel

The list shows all traces that are stored. By use of the controls in the **Show traces for** frame, you can filter out which traces to show. The EUN code entered may start and/or end with the wild character “*”. Only the traces with an EUN that matches the entered value will be displayed.

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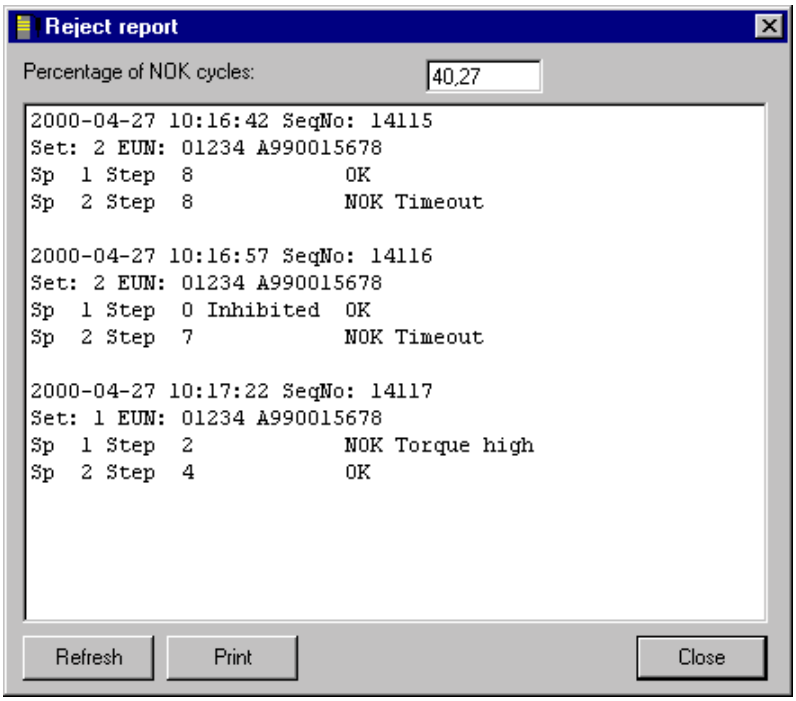
Report

View Reject…

This function invokes the Reject Report window, which presents a reject report based on the last 1000 cycles. The data collected for each NOK cycle is stored on disk.


Reject report
Percentage of NOK cycles: 40,27
2000-04-27 10:16:42 SeqNo: 14115
Set: 2 EUN: 01234 A990015678
Sp 1 Step 8 OK
Sp 2 Step 8 NOK Timeout
2000-04-27 10:16:57 SeqNo: 14116
Set: 2 EUN: 01234 A990015678
Sp 1 Step 0 Inhibited OK
Sp 2 Step 7 NOK Timeout
2000-04-27 10:17:22 SeqNo: 14117
Set: 1 EUN: 01234 A990015678
Sp 1 Step 2 NOK Torque high
Sp 2 Step 4 OK
Refresh
Print
Close

The Reject Report window displays a list of all NOK cycles. For each NOK cycle the following are listed:

- Date and time for the start of the cycle
- The EUN code
- The set of the cycle
- A sequence number that is the same as the sequence number in MMS

And for each spindle in the station:

- The spindle number
- The step number of the reported step
- Whether or not it is inhibited
- Status (OK/NOK)
- The reject cause if status is NOK

Above the list the percentage of NOK cycles (number of NOK cycles/1000 * 100)

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are shown.

Press the button **Refresh** to refresh the current list and press the button **Print** to have the current view on paper. To print only a part of the list, make a selection in the list, press **Print** and choose Print Selection.

End of shift report

You can set up that an End of Shift Report should be printed automatically at the end of each shift. The report consists of the following data:

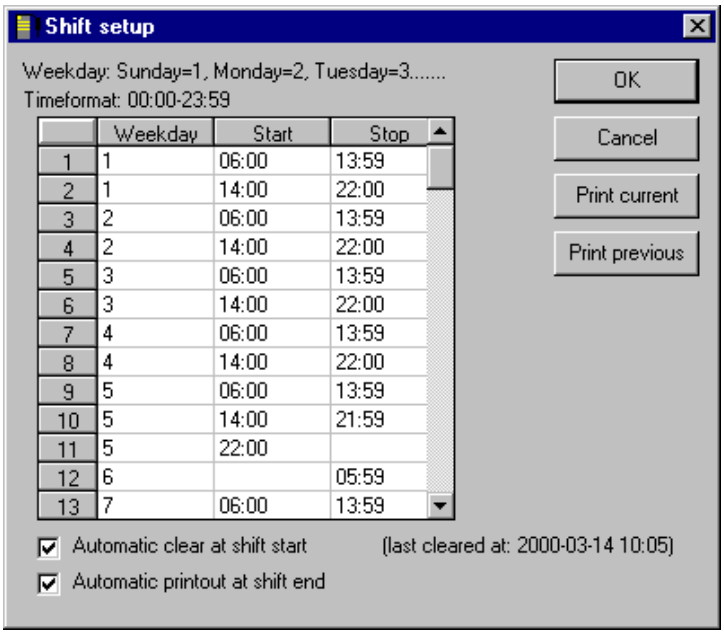
The number of cycles executed since buffers where cleared (see below when buffers are cleared)

The number and percentage of NOK cycles executed since buffers where cleared.

The average, +/- 3 sigma, Cp and Cpk, for all variables currently set up to be monitored for SPC, at the end of the shift. These variables are calculated on the SPC and TDA data buffer.

Note: The calculations of these variables are not reset when the other buffers are cleared (e.g. at the start of a shift).

To set up when the end of shift reports should be printed select the menu alternative **Report/Define End of Shift…**. It will cause the following form to be displayed:



	Weekday	Start	Stop
1	1	06:00	13:59
2	1	14:00	22:00
3	2	06:00	13:59
4	2	14:00	22:00
5	3	06:00	13:59
6	3	14:00	22:00
7	4	06:00	13:59
8	4	14:00	22:00
9	5	06:00	13:59
10	5	14:00	21:59
11	5	22:00	
12	6		05:59
13	7	06:00	13:59

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In this dialogue you can define the start and end of each shift using a weekly calendar. A shift that ends on another day than it starts on is defined using two rows in the grid. The start time is defined on the first line with the stop time left blank. The stop time is defined on the second row with the start time left blank.

You may also specify whether or not the cycle buffers should be cleared at the start of each shift and whether or not the report should be printed automatically at the end of the shift.

The field **last cleared at** shows the time when the buffers where last cleared.

Press the **Print Current** button if you want to force the printout of the report for the currently running shift. The report will then be based on the data collected since the buffers where last cleared up till now.

It is also possible to print the previously generated shift report. This is done pressing the **Print Previous** button.

The reports are printed to the printer set up as the default printer on the NT system.

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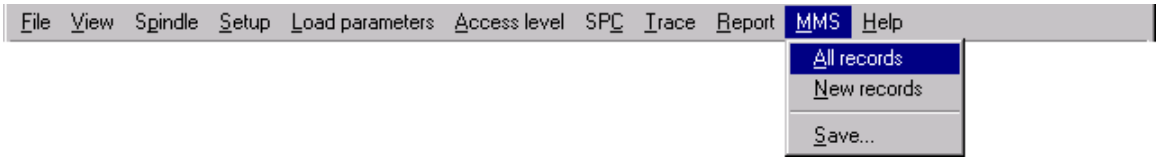
MMS



All records

Fills The MMS Window with the records of all cycles currently stored in the MMS queue.

New records

Fills The MMS Window with the records of all cycles currently stored in the MMS queue that have not yet been read by the MMS server

Note: To update the window with latest data you must actively select either of the two alternatives above. The window is not automatically updated when new cycle data becomes available.

Save

Stores the data currently displayed in the MMS window to disk.

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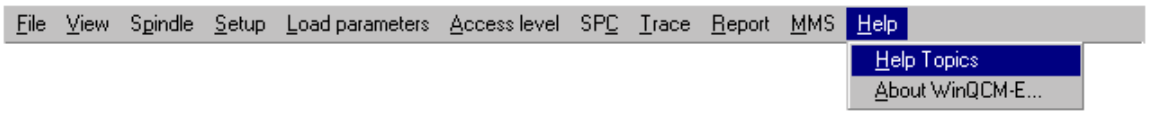
Help menus



Help Topics

Starts the help file for WinQCM-E.

About WinQCM-E

Displays the WinQCM-E about box where you can se the version number of the program.

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Toolbar

Following functions are in the toolbar: **New**, **Open**, **Save**, **Print**, **Select current servo**, **On-line/Off-line**, **Log** and a **StatusLight**.

Select current servo is a pop-down menu with following selections: Servo 1, servo 2, ..., servo 32.

On-line/Off-line has the text on-line. In on-line the button appears pressed and above the text three dots shows up and disappear. When off-line the button looks to be in its upper position.

A parameter change in On-line mode is written directly to the spindle and it can be seen that the three dots change colour (normally from blue to red) during the transmission time.

New, **Open** and **Save** are standard window symbols and will create, open, or save the set-up.

Log will activate the saving of data to a file.

There is also a **StatusLight** that indicates the connection with the StationController. This light has three different colours:

Grey	WinQCM is offline.
Red	WinQCM is online, no connection with StationController. Either OpenControl is not started or there is an error in the conneciton.
Green	WinQCM is online, connection with StationController is OK.

The status light can be disabled by setting a value in the ini-file. Section is [STATIONCONTROLLER] and the key is STATUSLIGHT (value 0,1).

Language

The program is available in English, German and French.

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The MMS Interface

General

The *mini*MACS MMS server running on the *mini*MACS PC will access the WinQCM application in order to read cycle data. WinQCM keeps the 100 last cycles in memory and save this buffer on disk whenever the application is closed normally. However, if the application should terminate for other reasons the buffer data may be lost. The number of cycles kept in memory can be changed in the ini-file (Section [MMS], key FIFOQUEUESIZE).

The interface available to the MMS server is implemented as a socket. Only one client at the time is accepted. The port number is default set to 5555 but can be defined in the ini-file (section [MMS], key PORTNO). The interface only supports one task at the time, meaning that a new request is not accepted until the previous is finished.

The interface supports the following telegrams:

- Request for all cycle data currently stored (a FIFO buffer with 100 slots)
- Request for all new cycle data since last request
- Cycle data (response from WinQCM)
- End of cycle data (response from WinQCM)
- Unknown telegram received (response from WinQCM)

The telegrams are of variable length and their contents should be interpreted as ASCII characters, i.e. as text. All telegrams have the following basic format:

```
STX <telegram type> <message body> ETX
```

where

`STX`	Start of text (decimal ASCII-code 2). One byte.
`<telegram type>`	One byte identifying the type of telegram
`<message body>`	The message. A message of variable length, zero or more bytes. The contents depends on the <telegram type>
`ETX`	End of text (decimal ASCII-code 3). One byte.

Request for all cycle data currently stored

This telegram is sent to WinQCM from the MMS server when it wants all cycle data currently stored.

The telegram has the following format (it has no message body):

`<telegram type>` “1” (decimal ASCII-code 49)

`<message body>` not valid

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Example: `STX 1 ETX` (or as decimal ASCII codes: 02 49 03)

WinQCM responds by sending one telegram for each cycle data currently stored. The data for the oldest cycle will be sent first, the second oldest is sent in the second telegram, and so on until all cycles stored are transferred.

To indicate that all cycle data are transferred WinQCM sends an end of cycle data telegram. If there are no cycle data recorded this is the only telegram sent.

Request for all cycles not currently read

This telegram is sent to WinQCM from the MMS server when it wants the cycle data of all cycles recorded since the last request for cycle data.

The telegram has the following format (it has no message body):

`<telegram type>`	"2" (decimal ASCII-code 50)
`<message body>`	not valid

Example: `STX 2 ETX` (or as decimal ASCII codes: 02 50 03)

WinQCM responds by sending one telegram for each cycle data currently stored that has not been sent earlier. The data for the oldest cycle is sent first, the second oldest is sent in the second telegram, and so on until all stored and unread cycles are transferred.

To indicate that all cycle data are transferred WinQCM sends an end of cycle data telegram. If there are no cycle data recorded, which have not already been read, this is the only telegram sent.

Cycle data

This telegram is sent to the MMS server from WinQCM as a response to any of the cycle data-requests. Each telegram contains the information of one cycle data. It consists of the following data:

Sequence number	A sequence number. Incremented for each cycle data read by WinQCM. First cycle data read when WinQCM do not have any cycles in the buffer is given the value 1
New record	1 = the record has not been returned earlier
Station name	

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The number of spindles in the station	
EUN	
Date and time for when the cycle was started	yyyy-mm-dd hh:mm:ss
Set number executed	
Overall cycle result	OK/NOK

For each spindle in the station the following is added:

Spindle x Final Torque	Unit as set up in WinQCM
Spindle x Min Torque Limit	Unit as set up in WinQCM
Spindle x Max Torque Limit	Unit as set up in WinQCM
Spindle x Final Angle	Unit as set up in WinQCM
Spindle x Min Angle Limit	Unit as set up in WinQCM
Spindle x Max Angle Limit	Unit as set up in WinQCM
Spindle x Inhibited	1 = spindle was inhibited
Spindle x Status	Status as returned by the servo

Whenever this telegram is sent to the MMS server the corresponding cycle data stored in the WinQCM is marked as read. This flag is used to figure out which cycle data that will be returned by the command “Request for all cycle not currently read”.

The telegram has the following format:

`<telegram type>` “3” (decimal ASCII-code 51)

`<message body>` See below

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Format of the cycle data message body

The cycle data message is an ASCII string following the syntax described below (extended BNF). Texts printed in boldface are to be taken literally.

```
<message body> ::= [HEAD] EOL
                   <SeqNo> EOL
                   <NewRecord> EOL
                   <StationName> EOL
                   <EUN> EOL
                   <Date> EOL
                   <Time> EOL
                   <SetNo> EOL
                   <CycleResult> EOL
                   <NoOfSpindles> EOL
                   [SPINDLES] EOL
                   <optSpindleList>


<optSpindleList > ::= <spindle> <optSpindleList> | NOTHING


<spindle>         ::= <spindleNo> HT <finalTorque> HT <MinTorqueLimit> HT
                      <MaxTorqueLimit> HT <finalAngle> HT <MinAngleLimit>
                      HT <MaxAngleLimit> HT <inibited> HT <Status> EOL


<SeqNo>         ::= <numStr>       (a sequnce number)
<NewRecord>     ::= 1 | 0          (1 indicates that this cycle data is
new)
<StationName>   ::= <alphaNumStr>  (name of the station)
<EUN>           ::= <alphaNumStr>  (EUN code as supplied from the
Automation PC)
<Date>          ::= <dateNumStr>   (date when the cycle was started)
<Time>          ::= <timeStr>      (time when the cycle was started)
<SetNo>         ::= <numStr>       (set number executed for the cycle)
<CycleResult>   ::= OK | NOK       (overall cycle result)
<NoOfSpindles> ::= <numStr>        (number of spindles in the station)


<spindleNo>       ::= <numStr>       (the spindle number)
<finalTorque>     ::= <floatStr>     (the final torque reported for the
cycle)
<MinTorqueLimit>  ::= <floatStr>     (min allowed torque)
<MaxTorqueLimit>  ::= <floatStr>     (max allowed torque)
<finalAngle>      ::= <floatStr>     (the final angle reported for the
cycle)
<MinAngleLimit>   ::= <floatStr>     (min allowed angle)
<MaxAngleLimit>   ::= <floatStr>     (max allowed angle)
<inibited>        ::= 1 | 0          (1 indicates that spindle was
inhibited)
<Status>        ::= <TimeOutExceeded> <MinAngleNotReached>
```


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```
                    <MaxAngleExceeded> <MinTorqueNotReached>
                    <MaxTorqueExceeded> <MStopActivated>
                    <SpindleError> <CalibrationError>
                    <OffsetError> <OverFlowError> <DCBusLow>
                    <FinalTorqueOK> <FinalAngleOk>

<TimeOutExceeded>     ::= 1 | 0   (1 indicates that the event occurred)
<MinAngleNotReached>  ::= 1 | 0   (1 indicates that the event occurred)
<MaxAngleExceeded>    ::= 1 | 0   (1 indicates that the event occurred)
<MinTorqueNotReached> ::= 1 | 0   (1 indicates that the event occurred)
<MaxTorqueExceeded>   ::= 1 | 0   (1 indicates that the event occurred)
<MStopActivated>      ::= 1 | 0   (1 indicates that the event occurred)
<SpindleError>        ::= 1 | 0   (1 indicates that the event occurred)
<CalibrationError>    ::= 1 | 0   (1 indicates that the event occurred)
<OffsetError>         ::= 1 | 0   (1 indicates that the event occurred)
<OverFlowError>       ::= 1 | 0   (1 indicates that the event occurred)
<DCBusLow>            ::= 1 | 0   (1 indicates that the event occurred)
<FinalTorqueOK>       ::= 1 | 0   (1 indicates that the event occurred)
<FinalAngleOk>        ::= 1 | 0   (1 indicates that the event occurred)

<alphaNumStr>   ::= A sequence of alpha numerical characters, including
space
<numStr>        ::= A sequence of numerical characters
<floatStr>      ::= A sequence of numerical characters, and an optional
                    dot as decimal point, that can be interpreted as a float value.
<dateStr>       ::= A sequence of characters that makes up a date,
                    formatted as
                    yyyy-mm-dd
<timeStr>       ::= A sequence of characters that makes up a time,
                    formatted as
                    hh:mm:ss
```

HT = <Horizontal tab> (decimal ASCII-code 9)

EOL = <Carriage return><Line feed> (decimal ASCII-codes 13 and 10)

Example of the message body:

```
[HEAD]
99
1
Flywheel
11ABC 990260001
1999-01-28
15:50:51
```


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```
2
NOK
2
[SPINDLES]
1  2.2    1.0    3.0    120.0  60.0   360.0  0      000000000011
2  2.3    1.0    3.0    420.0  60.0   360.0  0      001000000010
```

End of cycle data

This telegram is sent to the MMS server from WinQCM to indicate that there are no cycle data to transfer.

The telegram has the following format (it has no message body):

`<telegram type>`	“4” (decimal ASCII-code 52)
`<message body>`	not valid

Example: `STX 4 ETX` (or as decimal ASCII codes: 02 52 03)

Unknown telegram received

This telegram is sent to the MMS server from WinQCM to indicate that it has received an unknown telegram.

The telegram has the following format:

`<telegram type>`	“0” (decimal ASCII-code 48)
`<message body>`	MMS_SERVER: Unknown message <receivedTgmType> <receivedMsgBody>

Example: `STX 0 MMS_SERVER: Unknown message <8> <xxxx> ETX`

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The Station Controller

General

The Station Controller is responsible for the co-ordination of the individual servos. It takes its input from the overriding Automation PC and controls the individual servos via a FBU (Field Bus Unit).

The Station Controller is implemented as an OpenControl application and interfaces both the Automation PC and the FBU using Profibus. For information on OpenControl see [Ref.08].

The following sections describes the function of the Station Controller. It does not describe how it is designed or how it can be modified, e.g. in order to handle group based reject management.

The interface to the Automation PC is described in Appendix 2: Interface to the Automation PC. For descriptions of the interface to the FBU see Appendix 3: FBU Profibus interface.

There is also a version of the Station Controller that is controlled via a discrete digital I/O interface. This so called manual version of the Station Controller is used for stations where control input and output typically are handled using push buttons and lamps. Except for the interface to the overriding control the functions of the manual version is the same as for the standard version. See section 4.7 Interface of the manual Station Controller for a description of the interface of the manual version.

Common terms

Term	Definition
Cycle	The complete execution of a set. May be terminated before all steps of the set have been executed. Results are reported to the WinQCM-E on cycle basis.
Tightening cycle	A tightening cycle includes the execution of the normal tightening set as well as any reject management set. I.e. a tightening cycle may consist of several cycles.

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Basic functionality

The main function of the Station Controller is to start and stop the tightening cycles, as ordered by the overriding Automation PC, and to handle reject management. It also co-ordinates transferring of quantitative cycle data between the WinQCM-E and the servos.

To use the Station Controller together with a particular tightening set-up, defined using the WinQCM-E, a number of parameters must be set up in the Station Controller application before it will work properly. The most important is the parameter NoOfSpindles, which defines the number of spindles controlled by the station, but there are also a number of parameters that controls handling of reject management, see 4.4 Reject management.

The Station Controller application program must be modified with the correct value of these parameters and be recompiled using the OpenControl development environment. The parameters may also be set using the OpenControl Monitor but then the values need to be set whenever the Monitor is restarted.

The execution of the station is controlled by an external controller, e.g. a PLC or Automation PC, using the input and outputs signals described in section 4.5 Interface to the Automation PC.

A typical sequence performed by the Station Controller looks like the following:

1. The Automation PC sets up the EUN code for the piece to be operated on, inhibit any spindles that should not be used, and defines the tightening set that should be used.
2. The Automation PC starts the tightening cycle by raising the Start signal.
3. The Station Controller checks that the system (i.e. FBU and servos/spindles involved) is OK. If not the tightening cycle is immediately terminated.
4. If the system is found OK the station starts the cycle. If all spindles do not start, or if they do not confirm the ordered set number, within 1 second the tightening cycle is terminated.
5. When the cycle finishes the station triggers the WinQCM-E to fetch cycle data from the spindles. If all spindles finish with status OK then the tightening cycle is ended and the station output OK is set.
6. If the cycle finishes NOK and reject management is enabled then the spindles are first backed using the defined back-off set. However, before starting the back off it orders the WinQCM-E to freeze the values currently displayed in its Result view. If the back-off cycle finishes OK then all spindles that where backed are re-tightened using the defined re-tightening set. During this phase the Station Controller orders the WinQCM-E to update the status of all spindles being re-tightened.
7. If the re-tightening cycle finishes with OK result the tightening cycle is ended and the station reports OK as the final result. If not the Station Controller will execute the configured 2nd failure action.

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During this sequence the Station Controller continuously reports its status.

All sets are executed in a synchronised manner, i.e. the execution of a step is not started for any of the spindles until all spindles have finished executing the previous step.

The execution of any on-going tightening cycle is immediately terminated if the Automation PC raises the Stop signal.

If a spindle indicates an error not classified as a tightening related error it must be reset. Generating a positive edge on the Reset input does this.

The Station Controller will control how the WinQCM-E reports data in its Result window, see 2.2.1 The Results Window, so that it always present the result of the last tightening cycle, even if the tightening cycle is ended by running a back off set.

See 4.6 The logic of the Station Controller for a more detailed description of operations of the Station Controller.

Reject management

All reject management is based on executing special sets for the back-off and re-tightening cycles when the ordinary cycle fails. You can choose between three types of reject management, Standard RM, Group based RM and Group based RM with priority. The basic difference between them is the condition for when a RM action is started.

When running Standard RM all spindles are monitored as a single group and the reject management action is started when the total number of faulty spindles are greater than a value specified for the specific set executed. When the condition is met all spindles, that still runs, are stopped.

When running Group based RM the spindles are divided in groups. Each group is monitored separately and each of them may specify different values for the maximum number of faulty spindles in the group. When the specified condition is met for a group only the spindles belonging to the group is stopped, all other spindles continue to execute.

Group based RM with priority differs from Group based RM only on one condition. When the reject management condition is fulfilled for a given group, say N, then all spindles belonging to all groups with identity greater than N also will be stopped.

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Which type of reject management to use is set up using the parameter RM_Type which takes one of the following values:

- 0 Standard RM
- 1 Group based RM
- 2 Group based RM with priority

Independently of the reject management type selected the following five parameters must be defined for all normal tightening sets:

- Setxx_RM_MaxFailedSpindles: Max number of failed spindles to allow only the failed spindles to be backed.
- Setxx_RM_BackOffSet: The number of the set that will be used to back-off the spindles.
- Setxx_RM_ReTighteningSet: The number of the set that will be used re-tighten the spindles. Usually the same as the normal tightening set.
- Setxx_RM_2ndFailureAction: The second failure action, 0 leave the joint, as it is, 1 back off the remaining NOK spindles, and 2 back off all spindles.
- Setxx_RM_2ndFailureSet: The number of the set that will be used to back-off the spindles during the second failure action.

The above four parameters all have the value zero (0) by default and must be set to correct values before running the station. See 6.4.2 Setting the OpenControl parameters for how to do this.

Note: From statistical point of view (SPC, Reject Report, etc.) all cycles are treated the same. This means that cycle data generated when executing a reject management set is recorded, just as any for any other cycle. However, different set numbers may distinguish them.

Standard Reject Management

Standard Reject management operates as follows:

- All steps are executed synchronously by all spindles, i.e. the next step is not started on any spindle until the current step is finished by all spindles. Whenever a step is finished (on all spindles) the Station Controller checks how many spindles that currently report NOK. This number is compared to the value of the parameter “Max number of failed spindles to allow only the failed spindles to be backed”.
- If it is less or equal the Station Controller will start the execution of the next step for all spindles that still have status OK. If it is greater then the on-going cycle is terminated by machine stopping all spindles. This will cause all still OK spindles to become NOK and report Machine Stop.
- If the cycle finishes with status NOK, i.e. at least one spindle failed, the reject management function is activated.
- Based on the number of NOK spindles, either all spindles or only the NOK spindles will be backed using the back-off set. If the back-off cycle ends successfully, yet another set will be used to re-tighten the joints.

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Should the back-off cycle fail then the station will not try to run the specified re-tightening set but stop and report NOK for the overall cycle.

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- Should the station status still be NOK after the re-tightening cycle then there is a programmable choice to either back off all spindles, the remaining NOK spindles or to leave the joint as it is.

Group Based Reject Management

When running Group Based Reject Management the following additional parameters must be defined in the Station Controller:

- RM_NoOfGroups: Defines how many groups the spindles are divided into.
- RM_MaxNoOfFailedSpInGroupxx: Defines how many spindles that may be faulty in group xx before the remaining spindles in the group are stopped.
- RM_GroupNoFor_Spxx: Defines to which group spindle xx belongs.

The set specific parameter SetX_RM_MaxFailedSpindles is used also when running group based RM. In this case it only defines how many spindles that may be faulty, regardless of group belonging, while still **only** the faulty spindles will be backed when executing the Back Off set.

Note: When using group based reject management all normal tightening sets must have a Delay End step as the last step in the set.

Group based reject management operates as follows:

- All steps are executed synchronously by all spindles, i.e. the next step is not started on any spindle until the current step is finished by all spindles. Whenever a step is finished (on all spindles) the Station Controller checks how many spindles that report NOK in each of the groups. This number is compared to the value of the parameter RM_MaxNoOfFailedSpInGroupxx.
- If it is less or equal the Station Controller will start the execution of the next step for all spindles that still have status OK in the corresponding group. If it is greater then the on-going cycle is terminated by machine stopping all spindles in the group. This will cause all still OK spindles in the group to become NOK and report Machine Stop. If Group based RM with priority is selected than all spindle belonging to groups with higher group numbers also are stopped.
- If the cycle finishes with status NOK, i.e. at least one spindle failed, the reject management function is activated.
- Based on the total number of NOK spindles in the station, either all spindles or only the NOK spindles will be backed using the back-off set. If the back-off cycle ends successfully, the re-tightening set will be used to re-tighten the joints.

  Should the back-off cycle fail then the station will not try to run the specified re-tightening set but stop and report NOK for the overall cycle.
- Should the station status still be NOK after the re-tightening cycle then there is a programmable choice to either back off all spindles, the remaining NOK spindles or to leave the joint as it is.

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Interface to the Automation PC

The complete layout of the interface to the overriding Automation PC is presented in Appendix 2: Interface to the Automation PC. Here the most important features of this interface are described.

Inputs

The Station Controller, implemented in OpenControl, is controlled by the Automation PC using the following inputs (items printed in italic on grey background are optional and may be used if so wanted):

Signal	Description
The EUN code	The value of this signal (16 byte), sampled when a start is detected is used to mark the trace and cycle data generated during the execution of the complete tightening cycle.
The parameter set to executed	This signal consists of four bits and specifies the number of the set that should be used as the normal tightening program. Zero (0) correspond to the first set of the tightening program. This input is sampled when a start order is detected.
Inhibit of individual spindles	This signal consists of four bytes and is used to inhibit individual spindles. This input is sampled when a start order is detected.
Start	A positive edge on this signal starts the execution of a tightening cycle. After being started the Station Controller ignores new start orders until it is ready for a new start. This is indicated by the output signal "Ready for Start".
Stop	A high level on this signal stops the execution of a tightening cycle, if executing. All servos/spindles will be machine stopped. This signal has precedence over all other input signals.
Link alive	*This signal is optional. If the parameter "SuperviseAPCLink" is set to one (1) the Station Controller uses this signal to supervise the connection to the Automation PC. If found 0 (zero) the station will be stopped.*
Reset	A positive edge on this signal resets the system, i.e. the station controller logic as well as all servos/spindles. While the system is running (indicated by the output signal Running) new reset commands are ignored.

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Outputs

During, and after, a cycle the Station Controller indicate its status using the following output signals (items printed in italic on grey background are optional and may be used if so wanted):

Signal	Description
Running.	This signal is high when the station is executing a tightening cycle. While this signal is high all inputs but stop are neglected. When Running goes low the output signals are valid.
RM back off started.	This signal is set high when a back-off set is started. If set, it will remain high during the rest of the tightening cycle. See Reject Management for a description of back off.
RM re-tightening started.	This signal is set high when a re-tightening set is started. If set, it will remain high during the rest of the tightening cycle. See Reject Management for a description of re-tightening.
OK.	This signal is low when a tightening cycle is started and is set high if it finishes without any errors.
NOK.	This signal is low when a tightening cycle is started and is set high if it finishes with an error.
Communication error	This bit is set high when the communication with the FBU fails, or when the FBU fails to communicate with any of its spindles.
E-stop.	This signal is set high if all spindles reports that the DC-bus is low.
Parameter-set failure.	This signal is set high if the all spindles do not confirm the ordered set number. The evaluation is done when all spindles have started the execution of the cycle. This time is normally within 200-300 ms from that a start command is issued. Note that the set number confirmed by the spindles also is evaluated when any reject management cycle is started. This means that this signal may be set “in the middle” of a tightening cycle.
Confirmed set number.	This signal (four bits) is the set number confirmed by all the spindles if they all confirm the same set number. If not, this signal remains set to zero (0) and the signal Parameter-set failure is set high.
Stopped	*This signal is optional. Is set high if the Station Controller is stopped due to that the Automation PC issued a Stop order.*
Cycle Start Error	*This signal is optional. Is set if all spindles did not report that they are running within the time defined by the "CycleStartTimer "(1000 ms).*
FBU comm. Error	*This signal is optional. Is set high if the Station Controller have lost the contact with the FBU.*
WinQCM overrun	*This signal is optional. Is set high if the WinQCM did not finish reading cycle data within the time defined by the "WinQCMTimer" (3000 ms).*
Spindle Comm. Error	*This signal is optional. Is set high if the FBU loose contact with one or more spindles.*
NT crashed	*This signal is optional. Is set high if NT crashes.*
Ready for Start	*This signal is optional. Is set high when the Station Controller accepts a new start order. After that the signal Running goes low a new start is not accepted until the WinQCM has finished.*

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APC comm. Error	*This signal is optional. Is set high when the Station Controller has lost contact with the Automation PC. Only active if supervision is enabled using one of the parameters StopSignalIsNegated or SuperviseAPCLink*
Parameter Error	*This signal is optional. Is set high if the parameter NoOfSpindles is set higher than 32 or if parameter RM_NoOfGroups is set higher than 16.*

All output signals above except for Running are cleared when a start is detected. If set during the tightening cycle, they remain set until either a reset, or a new start, command is issued.

In addition to the output signals on the station level the following signals indicates the status of the individual spindles. Note that these signals are updated after each individual cycle:

Signal	**Description**
Cycle NOK.	Cleared at cycle start. Set high when a cycle finishes with an error and is cleared whenever a new cycle is started. If the spindle finished NOK during the last tightening phase (executing the normal or re-tightening set) this signal will be set just before the signal Running is cleared. Remains set until next start.
Spindle Bypassed.	High indicates that the spindle is inhibited by the Automation PC. This value is only changed at cycle start.
Torque NOK.	Cleared at cycle start. Set high when a cycle is finished and the reported torque is out of limit. If set, it remains high until next start.
Angle NOK.	Cleared at cycle start. Set high when a cycle is finished and the reported angle is out of limit. If set, it remains high until next start.
Controller OK/Ready.	High if the servo/spindle is OK and ready for start. A low value indicates a servo/spindle error. If set, it remains high until the system is reset.
Time out Error.	Set high if the maximum time out time parameter for a step is exceeded for a step executed. If set, it remains high until the system is reset or the next cycle is started.
Transducer Measure Error.	Set high if and when the servo/spindle detects a calibration error, an offset error, or an overflow error. If set, it remains high until the system is reset.
DC-Bus Low.	Set high when the DC-Bus voltage drops below the critical level. If set, it remains high until the system is reset.

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Timing diagram for a typical case

This timing diagram shows the valid time for signals and should be used as a help to understand how the enhanced *mini*MACS system works. The diagram does not intend to reflect the absolute timing but more the order in which signal are set.

All outputs are valid when the Running signal goes low. They will remain as set until a new start, or a reset command is issued.

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The logic of the Station Controller

The Station Controller can be described as a state machine with following states and transitions:

The actions taken in the different states are described in the following sections.

State Idle

The system is under initialisation. The Station Controller enters this state only once, and that is when the OpenControl Monitor starts the Station Controller application. Here some global data are set and the servos/spindles are initialised. The next state is always Waiting for start.

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State Waiting for start

In this state the Station Controller is ready to start a new tightening cycle. It continuously scans the reset and start signals, looking for a positive edge on either of them.

If a Reset order is detected then all Station Controller outputs are cleared and all servos are reset by generating a low pulse on the FBU input Controller On (the timer ResetTimer controls the length of this pulse). The Station Controller will in this case remain in the state Waiting for start.

If a Start order is detected the Station Controller will change state to Checking Spindles.

State Checking spindles

In this state the Station Controller checks for any error that should cancel a start. It checks that:

- the communication with the FBU is OK
- the communication between the FBU and all, not inhibited, spindles is OK
- all, not inhibited, servos/spindles report Controller OK and non of the following: General Hardware error, DC-Bus down, and Cycle Running.

If all conditions are found to be OK then following takes place:

- the value of the input signals EUN code, Set number, and Inhibit are sampled and stored
- all Station Controller outputs are cleared
- the output signal Running is set high

and the Station Controller changes its state to Running.

If an error is found then the start is cancelled and the state is changed to Waiting for start. The station output Communication error and/or the corresponding output signals for each spindle indicate the error, or errors, that caused the cancelling.

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State Running

The Station Controller is in this state while the normal tightening set is executed.

The first thing done is to initialise all, not inhibited, servos with the EUN code, Set number, and cycle start time according to the sampled value of the corresponding input values.

Secondly the servos/spindles are ordered to start the execution of the cycle. The Station Controller then supervises that all servos begin to execute the cycle within 1000 ms. If this fails, then the on-going cycle is terminated by machine stopping all spindles.

If the cycle is started on all servos within the given time then the set number confirmed by each of them is read back and compared against the ordered one. If an erroneous set number is detected then the output signal “Confirmed set number” is set high and the on-going cycle is terminated by machine stopping all spindles.

The Station Controller then continuously scans the status of all the spindles participating in the cycle in order to detect when they all have finished to execute the on-going step. When that is the case, it checks whether or not the cycle is finished and how many of the spindles executed during this cycle for which an error is reported. If this number is greater than what is allowed (set by the reject management parameter “MaxFailedSpindles” for the set) then the on-going cycle is terminated by machine stopping all servos.

If the cycle is finished the Station Controller evaluates the result of the cycle. It then supplies the WinQCM-E with parts of the cycle data (EUN, Cycle Start Time, Set number, etc.) and triggers the WinQCM-E to fetch the rest of the data needed directly from the servos.

If the cycle was found OK when evaluated then the tightening cycle is ended. The station output OK is set high, Running is set low, and the state of the Station Controller is changed to Waiting for start.

If the cycle was found NOK, and there is a valid reject management back-off set defined for the set, then reject management is started. This is indicated by setting the station output “RM back-off started” high and changing the state of the Station Controller to RM back-off.

If the cycle was found NOK and no back-off set is defined then the tightening cycle is ended. The station output “NOK” is set high, “Running” is set low, and the state of the Station Controller is changed to Waiting for start.

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If the cycle is not finished and no error is indicated, then the controller just starts the execution of the next step.

State RM back-off

The Station Controller enters this state when the first phase of reject management is started, i.e. the execution of the back-off set.

When state is entered the servos are prepared to run the back-off set. This is done as follows:

- if the normal cycle (state Running) resulted in that the number of failed spindles was less or equal to the parameter “MaxFailedSpindles” then all OK spindles are inhibited. This is done to ensure that only the NOK spindles are backed in this case. Otherwise all spindles are backed-off. See also Reject management.
- the number of set to back-off with, the original EUN-code and a new cycle start time is sent to the servos

Then all, currently not inhibited, spindles are started. The execution of the cycle and reporting to the WinQCM-E are controlled the same way as for the state Running except for that when the back-off cycle is finished different actions are taken depending on how it ends.

If the back-off cycle was found OK when evaluated, and there is a valid re-tightening set defined for the original set, then reject management continues with the re-tightening phase. This is indicated by setting the station output “RM re-tightening started” high and changing the state of the Station Controller to RM back-off.

If the back-off cycle was found NOK, or if no re-tightening set is defined, then the tightening cycle is ended. The station output “NOK” is set high, “Running” is set low, and the state of the Station Controller is changed to Waiting for start.

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State RM re-tightening

The Station Controller enters this state when the second phase of reject management is started, i.e. the execution of the re-tightening set.

When state is entered the servos are prepared to run the re-tightening set on all spindles that where backed. The servos are therefore set up with the following: the number of set to re-tighten with, the original EUN-code, a new cycle start time, and the same inhibit information as set up for the execution of the back-off set.

Then all, currently not inhibited, spindles are started. The execution of the cycle and reporting to the WinQCM-E are controlled the same way as for the states Running and Back-off except for that when the re-tightening cycle is finished the following actions are taken depending on how it ends.

If the re-tightening cycle was found OK then the tightening cycle is ended. The station output “OK” is set high, “Running” is set low, and the state of the Station Controller is changed to Waiting for start.

If the re-tightening cycle was found NOK when evaluated, and the 2nd failure action is set to either back-off all, or the currently NOK, spindles, then reject management continues with the 2nd failure action. The state of the Station Controller is therefore changed to 2nd failure.

If the re-tightening cycle was found NOK and the 2nd failure action is set to anything else but back-off all, or the currently NOK, spindles, then the tightening cycle is ended. The station output “NOK” is set high, “Running” is set low, and the state of the Station Controller is changed to Waiting for start.

State: 2nd Failure

The Station Controller enters this state when the if the re-tightening has failed and the 2nd failure action is set to either back off all spindles, or to back off only the currently NOK spindles. The spindles are backed using the same set as used for the back-off state.

When state is entered the servos are prepared to run the back-off set on either all spindles that where not inhibited by the Automation PC right from the start no matter their current status, or only the spindles that currently are not correctly tightened.

The servos are therefore set up with the following: the number of set to back-off with, the original EUN-code, a new cycle start time, and the inhibit information according to the above.

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Then all, currently not inhibited, spindles are started. The execution of the cycle and reporting to the WinQCM-E are controlled the same way as for the states Running, Back-off, and Re-tightening except for that when the cycle is finished the following action is always taken:

- The tightening cycle is ended. The station output “NOK” is set high, “Running” is set low, and the state of the Station Controller is changed to Waiting for start.

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Interface of the manual Station Controller

The standard versions interface to the overriding Automation PC is for the manual version replaced by a discrete digital I/O interface. The I/O modules are interfaced to as Profibus slaves on the same Profibus link as the FBU is connected to.

Depending on the number of spindles included in the station up to four I/O modules are used. They are used as follows:

- Module 1 (Profibus slave node 4): Includes the station general signals Start, Stop, parameter set, etc. and the spindle specific inputs and outputs for the first nine spindles.
- Module 2 (Profibus slave node 5): Coops with the inputs and outputs of the next 10 spindles, i.e. spindle 10 to 19.
- Module 3 (Profibus slave node 6): handles inputs and outputs of the 12 spindles numbered 20 to 31.
- Module 4 (Profibus slave node 7): Includes the interface of the last spindle, i.e. spindle 32.

Inputs

Module 1:

Chan.	Description	Comment
1	Stop	The Stop signal. See 4.5.1 Inputs for a description.
2	Start	The Start signal. See 4.5.1 Inputs for a description.
3	Parameter Bit 0	Tightening set binary bit 0 (value 1).
4	Parameter Bit 1	Tightening set binary bit 1 (value 2)
5	Parameter Bit 2	Tightening set binary bit 2 (value 4)
6	Lamp Test	If set high the following outputs will be set high: Station OK Station NOK Group X OK Group X NOK Spindle X Running or NOK
7	Reset	The Reset signal. See 4.5.1 Inputs for a description.
8	Inhibit Spindle 1	If set to 1 spindle will be bypassed next cycle
9	Inhibit Spindle 2	If set to 1 spindle will be bypassed next cycle
10	Inhibit Spindle 3	If set to 1 spindle will be bypassed next cycle
11	Inhibit Spindle 4	If set to 1 spindle will be bypassed next cycle
12	Inhibit Spindle 5	If set to 1 spindle will be bypassed next cycle
13	Inhibit Spindle 6	If set to 1 spindle will be bypassed next cycle
14	Inhibit Spindle 7	If set to 1 spindle will be bypassed next cycle
15	Inhibit Spindle 8	If set to 1 spindle will be bypassed next cycle
16	Inhibit Spindle 9	If set to 1 spindle will be bypassed next cycle

Module 2:

Chan.	Description	Comment
1-6	Not used	

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7	Inhibit Spindle 10	If set to 1 spindle will be bypassed next cycle
8	Inhibit Spindle 11	If set to 1 spindle will be bypassed next cycle
9	Inhibit Spindle 12	If set to 1 spindle will be bypassed next cycle
10	Inhibit Spindle 13	If set to 1 spindle will be bypassed next cycle
11	Inhibit Spindle 14	If set to 1 spindle will be bypassed next cycle
12	Inhibit Spindle 15	If set to 1 spindle will be bypassed next cycle
13	Inhibit Spindle 16	If set to 1 spindle will be bypassed next cycle
14	Inhibit Spindle 17	If set to 1 spindle will be bypassed next cycle
15	Inhibit Spindle 18	If set to 1 spindle will be bypassed next cycle
16	Inhibit Spindle 19	If set to 1 spindle will be bypassed next cycle

Module 3:

Chan.	Description	Comment
1-4	Not used	
5	Inhibit Spindle 20	If set to 1 spindle will be bypassed next cycle
6	Inhibit Spindle 21	If set to 1 spindle will be bypassed next cycle
7	Inhibit Spindle 22	If set to 1 spindle will be bypassed next cycle
8	Inhibit Spindle 23	If set to 1 spindle will be bypassed next cycle
9	Inhibit Spindle 24	If set to 1 spindle will be bypassed next cycle
10	Inhibit Spindle 25	If set to 1 spindle will be bypassed next cycle
11	Inhibit Spindle 26	If set to 1 spindle will be bypassed next cycle
12	Inhibit Spindle 27	If set to 1 spindle will be bypassed next cycle
13	Inhibit Spindle 28	If set to 1 spindle will be bypassed next cycle
14	Inhibit Spindle 29	If set to 1 spindle will be bypassed next cycle
15	Inhibit Spindle 30	If set to 1 spindle will be bypassed next cycle
16	Inhibit Spindle 31	If set to 1 spindle will be bypassed next cycle

Module 4:

Chan.	Description	Comment
1	Inhibit Spindle 32	If set to 1 spindle will be bypassed next cycle
2-16	Not used	

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Outputs

Module 1:

Chan.	Description	Comment
1	Station OK	Set high if a tightening cycle finished OK. See also description of signal OK in section 4.5.2 Outputs.
2	Station NOK	Set high if a tightening cycle finished NOK. See also description of signal NOK in section 4.5.2 Outputs.
3	Running	Set high when the station is running a cycle. See also section 4.5.2 Outputs.
4	System OK	Set low if any of the following is detected: Emergency Stop FBU/Servo communication error Set No. error Comm. error with any of the I/O modules When set low it remains low until a Reset or Start is detected.
5	Confirmed Parameter Bit 0	Confirmation of ordered tightening set. Binary bit 0 (value 1).
6	Confirmed Parameter Bit 1	Confirmation of ordered tightening set. Binary bit 1 (value 2).
7	Confirmed Parameter Bit 2	Confirmation of ordered tightening set. Binary bit 2 (value 4).
8	Running or NOK Spindle 1	A high value indicates that the spindle either is running or that it finished with a NOK result.
9	Running or NOK Spindle 2	A high value indicates that the spindle either is running or that it finished with a NOK result.
10	Running or NOK Spindle 3	A high value indicates that the spindle either is running or that it finished with a NOK result.
11	Running or NOK Spindle 4	A high value indicates that the spindle either is running or that it finished with a NOK result.
12	Running or NOK Spindle 5	A high value indicates that the spindle either is running or that it finished with a NOK result.
13	Running or NOK Spindle 6	A high value indicates that the spindle either is running or that it finished with a NOK result.
14	Running or NOK Spindle 7	A high value indicates that the spindle either is running or that it finished with a NOK result.
15	Running or NOK Spindle 8	A high value indicates that the spindle either is running or that it finished with a NOK result.
16	Running or NOK Spindle 9	A high value indicates that the spindle either is running or that it finished with a NOK result.

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Module 2:

Chan.	Description	Comment
1	Group 1 OK	Set high if all spindles included in group 1 finished the tightening cycle OK. See 4.4.2 Group Based Reject Management for a description of groups.
2	Group 1 NOK	Set high if any of the spindles included in group 1 finished the tightening cycle NOK.
3	Group 2 OK	Set high if all spindles included in group 2 finished the tightening cycle OK.
4	Group 2 NOK	Set high if any of the spindles included in group 2 finished the tightening cycle NOK.
5	Group 3 OK	Set high if all spindles included in group 3 finished the tightening cycle OK.
6	Group 3 NOK	Set high if any of the spindles included in group 3 finished the tightening cycle NOK.
7	Running or NOK Spindle 10	A high value indicates that the spindle either is running or that it finished with a NOK result.
8	Running or NOK Spindle 11	A high value indicates that the spindle either is running or that it finished with a NOK result.
9	Running or NOK Spindle 12	A high value indicates that the spindle either is running or that it finished with a NOK result.
10	Running or NOK Spindle 13	A high value indicates that the spindle either is running or that it finished with a NOK result.
11	Running or NOK Spindle 14	A high value indicates that the spindle either is running or that it finished with a NOK result.
12	Running or NOK Spindle 15	A high value indicates that the spindle either is running or that it finished with a NOK result.
13	Running or NOK Spindle 16	A high value indicates that the spindle either is running or that it finished with a NOK result.
14	Running or NOK Spindle 17	A high value indicates that the spindle either is running or that it finished with a NOK result.
15	Running or NOK Spindle 18	A high value indicates that the spindle either is running or that it finished with a NOK result.
16	Running or NOK Spindle 19	A high value indicates that the spindle either is running or that it finished with a NOK result.

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Module 3:

Chan.	Description	Comment
1	Group 4 OK	Set high if all spindles included in group 4 finished the tightening cycle OK. See 4.4.2 Group Based Reject Management for a description of groups.
2	Group 4 NOK	Set high if any of the spindles included in group 4 finished the tightening cycle NOK.
3	Group 5 OK	Set high if all spindles included in group 5 finished the tightening cycle OK.
4	Group 5 NOK	Set high if any of the spindles included in group 5 finished the tightening cycle NOK.
5	Running or NOK Spindle 20	A high value indicates that the spindle either is running or that it finished with a NOK result.
6	Running or NOK Spindle 21	A high value indicates that the spindle either is running or that it finished with a NOK result.
7	Running or NOK Spindle 22	A high value indicates that the spindle either is running or that it finished with a NOK result.
8	Running or NOK Spindle 23	A high value indicates that the spindle either is running or that it finished with a NOK result.
9	Running or NOK Spindle 24	A high value indicates that the spindle either is running or that it finished with a NOK result.
10	Running or NOK Spindle 25	A high value indicates that the spindle either is running or that it finished with a NOK result.
11	Running or NOK Spindle 26	A high value indicates that the spindle either is running or that it finished with a NOK result.
12	Running or NOK Spindle 27	A high value indicates that the spindle either is running or that it finished with a NOK result.
13	Running or NOK Spindle 28	A high value indicates that the spindle either is running or that it finished with a NOK result.
14	Running or NOK Spindle 29	A high value indicates that the spindle either is running or that it finished with a NOK result.
15	Running or NOK Spindle 30	A high value indicates that the spindle either is running or that it finished with a NOK result.
16	Running or NOK Spindle 31	A high value indicates that the spindle either is running or that it finished with a NOK result.

Module 4:

Chan.	Description	Comment
1	Running or NOK Spindle 32	A high value indicates that the spindle either is running or that it finished with a NOK result.
2-16	Not used	

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The Field Bus and Servo Units

General

The Field Bus Unit (FBU) is an intelligent communication controller, manufactured by Atlas Copco Controls [Ref.04]. It can be equipped for communication through all common field buses on the market, in this case the Profibus. The information from the Profibus is processed and transferred to the CAN based communication bus called Lan1, used by the servo drive units. This communication is further described in Appendix 3: FBU Profibus interface.

The servo drive units for the Enhanced *mini*MACS System are based on the new standard QCM2 drive units by Atlas Copco Controls [Ref.03]. These units have a new control card called CPU2 which includes all functions and I/O's necessary for the required performance, without any modifications. Up to 32 drive units can be connected together in a station with one Station Controller and one FBU.

The QCM2 units come in three different power ranges, 340V, 15-, 25-, and 50A, with or without internal power supply, i.e. Master (QCM2) or Slave QCS2). All sizes will be supplied with the same application software. The servo units communicates directly with the WinQCM-E using the CAN bus Lan2. See Appendix 4: QCM2 CAN Communication for a description of the protocol used.

The functionality control of the servo drive part of the tightening system is stored in two sets of application software, one for the QCM2 servo drive units and one for the FBU.

Basic Operation

From the FBU- and Servo-units a typical tightening cycle could look like this:

- A start command is sent from the Station Controller to the FBU through the Profibus interface. The FBU processes the data and transfers the start command to the servo drive units, through the Lan1 bus. Each drive unit responds to the start command by setting status signals and performs the chosen tightening set. The FBU retrieves status signals and qualitative data from all drive units through the Lan1 bus and transfers it back to the Station Controller through the Profibus interface.
- During the tightening cycle, each drive unit stores quantitative tightening data in its internal, register based memory as further described in chapter 5.4.1. When the tightening set is done the WinQCM-E retrieves the quantitative tightening data from the servo drive units through the Lan2 bus. This information is e.g. used for SPC (Statistical Process Control) calculations in the WinQCM-E.

When the start signal is received, the servo drive unit runs the motor according to a pre-programmed operation sequence stored in its internal memory. Each sequence or set contains one or more tightening steps, where each step contains

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one control mode defined by up to six parameters, for example torque, angle, speed, time, etc. See Tightening steps for a description of the different control modes.

The program capacity of a servo drive unit allows for storing of parameters for 64 steps. The steps can be combined in up to 64 sets. Programming is performed using the WinQCM-E, and the parameters are sent to the drive units through the Lan2 bus.

Since each drive unit can perform up to 16 different tightening sets, the appropriate set number has to be selected before the start signal is sent. The selected set number is the same for all drive units in the station, but the content of the set (i.e. the steps) can vary between the drive units. Each drive unit can be bypassed by an ”inhibit” signal, implying that it will not run a cycle at the start command. The “Start of Cycle Time” and EUN codes must be included in the start command signal.

At the end of each tightening cycle the servo drive unit will store the final torque and angle values in its internal memory. These values together with “Start of Cycle Time” and EUN (Engine Unit Number) are then retrieved by the WinQCM-E through the Lan2 bus for SPC calculations and reporting.

Cabling

For proper operation and functionality of the servo drive system, all cables must be connected according to the user’s manuals for QCM2 [Ref.03] and FBU [Ref.04]. Ground and shield connections must also be performed according to the installation instructions.

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The QCM2 Servo Unit

Traces

During each tightening cycle the servo drive unit stores measured torque and angle values in its internal memory with a resolution of 1ms/sample. A maximum of 2000 samples per trace can be stored. Each such trace is stamped with ”Start of Cycle Time” and combined with Stepstatus and EUN. The servo drive unit will store the last 10 OK/NOK traces plus the last 10 NOK traces in its internal memory. Upon request by an operator the WinQCM-E will ask a servo unit for retrieval of the selected trace over the Lan2 bus.

Digital I/O

A digital I/O port is available on the servo drive unit aimed for testing and commissioning. Two modes are available:

- Operation mode: This is the standard mode when running the system. Discrete I/O is disabled and replaced by the Lan1 signalling as defined in Appendix 3: FBU Profibus interface.
- Commissioning mode: Commissioning mode is selected by setting digital input X7A:8 to logic one. Control over the Lan1 bus is disabled and the servo drive unit uses discrete I/O signalling instead. This mode is only to be used for low level testing and debug purposes with reduced functionality.

Indicators

There are ten LED indicators available on the front panel of the servo drive unit. The upper two are controlled by hardware:

- Power On. Green LED, lit when +5V is available in the controller section.
- CPU OK. Green LED, lit when the CPU has started up and is running.

The remaining eight LED’s (1xGreen, 3xYellow, 4xRed) are controlled by the application software.

LED	Signal Name	Color	Description
1	Ready	Green	Servo drive is ready to accept a start signal.
2	Running	Yellow	Servo drive is running a tightening set.
3	Selected	Yellow	Servo drive is selected for communication.
4	Current Limit	Yellow	Current limit exceeded in the servo drive unit.
5	Overtemperature	Red	Overtemperature in the motor or in the servo drive unit.
6	Resolver Fault	Red	A resolver fault is detected.
7	Overcurrent	Red	A short circuit is detected in the motor or the motor cables.
8	Other Faults	Red	A fault is detected, other then the three listed above.

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Start up Instructions

General

This section describes typical tasks involved in commissioning of a miniMACS system.

Hardware check

FBU

Adjust the Profibus address of the FBU to 32. Switch location at back (Mounting plate) = 2, switch at front = 3.

DIP – Switch for the end resistor = ON (if last in chain and the connector do not have an end switch or end switch is off)

Profibus cable

Cable must be a shielded twisted par cable type AWG 24. The DIP –switches on the connectors according to the amount off slaves.

Discret IO card

If discreet IO is used then check the addresses. Normally the first card should have address 04 and the second 05.

PC

Open the cover of the PC and check the setting of the DIP-switches on the Kvaser CAN bord. They should be set as the following (1 = ON and 0 = OFF):

	1	2	3	4	5	6	7	8	9	10
SW2	1	1	0	0	0	0	1	1	1	1
SW3	0	0	0							

Lan1

Check that the two “end of chain connectors”, with 120 Ohm resistors, are mounted (15 pol. HD-Connector, Pin 13/14).

At FBU	= (marked with) Host
At the last Servo	= (marked with) Next

Lan2

Check that the 24 V power supply is supported to the last servo in chain. (Pin6-24V, Pin9-GND, 120 Ohm resistor between 2-7)

UPS

Check that the serial cable is connected to COM1 on the PC.

Servo connectors

K7A-B:

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Ensure that K7A:6 is connected with K7B:34 on all servos.

Attention!

For servos which should have servo addresses above 15 you must install a jumper as follows:

For addresses between 16 and 30:	Connect K7B:27 with K7A:16.
For addresses above 31:	Connect K7B:27 with K7A:15.

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Software

Needed software and files

Software	Files (names may vary)	Remark
Servo application	Proda_03.HEE	1 disk
FBU application	FBU_1.HEE	1 disk
ProMotion v3.xx ECT (Edit Compile Test)		1 disk
Station Controller ver. 1.4 or later (Open Control application)	SC_Setup.EXE	1 disk
WinQCM-E ver.99.22, or later		3 disks

Install Promotion (ECT).

Run “Install.EXE” and follow the instructions.

Install WinQCM-E

Run “Setup.EXE” and follow the instructions.

Install the Station Controller

Run the self extracting program “SC_Setup.EXE”.

Down load Servo software

Copy the servo application software (*.HEE) to the directory \ATLAS\SERVO\

Repeat the following for each servo in the system:

1.	Plug PC into Host Port on front of each servo one at a time Start with left most servo and work to right
2.	Make sure servo is powered up.
3.	Start ECT software on the PC.
4.	Select **Window/Terminal** from menu (you are now in terminal mode).
5.	Setup servo software: Type “**CRTL-Z, X**”, where “X” represents the address for the servo.
6.	Select **Controller/Force terminal mode** from menu.
7.	Select **Controller/Download** from menu. Select the servo application software and press OK to download.
8.	You can monitor the download status at the bottom left of screen.
9.	Type “**FSTORE**” to store new file in Servo memory.
10.	Type “**RESET SYSTEM**” to reset system (Servo software will now restart again). This always resets the node address to “1”.
11.	If you want to be certain that the downloaded version is the correct one, continue with the following: Type “**CTRL-Z 1**”. Wait for response of servo, select **Controller/Force terminal mode** from menu, then type **“DISP EEPROM.63**” and hit **ENTER**. As a result the version of the servo application software will be displayed. It will look similar to the following: “1999220401”

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12.	Setup correct servo address: Servos are addressed 1-15, starting from the left most servo going right. When specifying the servo address using ECT software we must use hexadecimal notation. Therefore 1-15 will be 1-F hexadecimal. Type "**CTRL-Z 1**". Then select Controller/Force terminal mode from menu and wait until the servo displays its address.
13.	Type "**CTRL-C**, **CTRL-C**" to stop the servo software.
14.	Type "**EEPROM.6, 241**" for servo address 1 (242 for servo address 2, etc.). Note: 241 = 240 + Node # = 240 + 1. See also the servo adress table below.
15.	Type "**RUN3**" to startup servo software with new node number
16.	Unplug the PC, the Servo is now set up. Goto Next Servo.

Servo address table

Servo or FBU number	Eeprom.6, Value	Hex Address
0	240	0
1; 16; 31	241	1
2; 17; 32	242	2
3; 18	243	3
4; 19	244	4
5; 20	245	5
6; 21	246	6
7; 22	247	7
8; 23	248	8
9; 24	249	9
10; 25	250	A
11; 26	251	B
12; 27	252	C
13; 28	253	D
14; 29	254	E
15; 30	255	F

Down load FBU Software

Copy the FBU application software (*.HEE) to the directory *\ATLAS\FBU*

Then do the following:

1.	Setup FBU address and load down software into FBU
2.	Plug PC into host port on front of FBU
3.	Load the FBU application software onto PC hard drive (this is FBU software)
4.	Select Window/Terminal (you are now in terminal mode)
5.	Make sure FBU is powered up

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6.	If the FBU does not respond by displaying its address, type “**CTRL-Z X**” where “X” represents the current FBU address. E.g.: “**CTRL-Z 0**” opens communication with selected unit. Then select **Controller/Force terminal mode** and wait until FBU displays its address, e.g.: “>” for address 0, “1>” for address 1, etc.
7.	Download FBU software: Select **Controller/Download**
8.	Select the FBU application software and press OK to download.
9.	You can monitor the download status at the bottom left of screen.
10.	Type “**FSTORE**” to store new file in FBU memory
11.	Type “**RESET SYSTEM**” to reset system (FBU software will now start)
12.	Change the FBU Node address to 0. Default is F (case sensitive).
13.	Type “**CTRL-Z F**”
14.	Type “**EEPROM.6, 240**” for FBU address 0
15.	Type “**R50,1**“
16.	Type “**RESET SYSTEM**” to reset and set node number
17.	Unplug the PC, the FBU is now set up.

Install NET UPS Lansafe program

Put in the CD and run \Lansafe\NTWin\Setup.exe. Select “NetUPS”.

After this port ‘COM1’ willl not be available for any other program.

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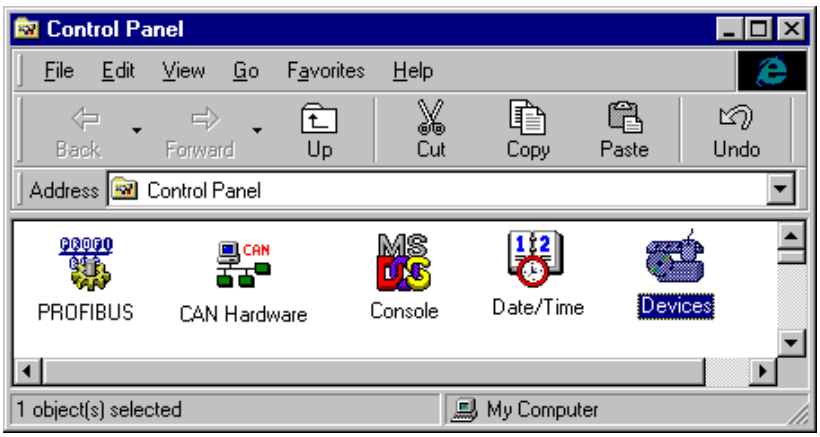
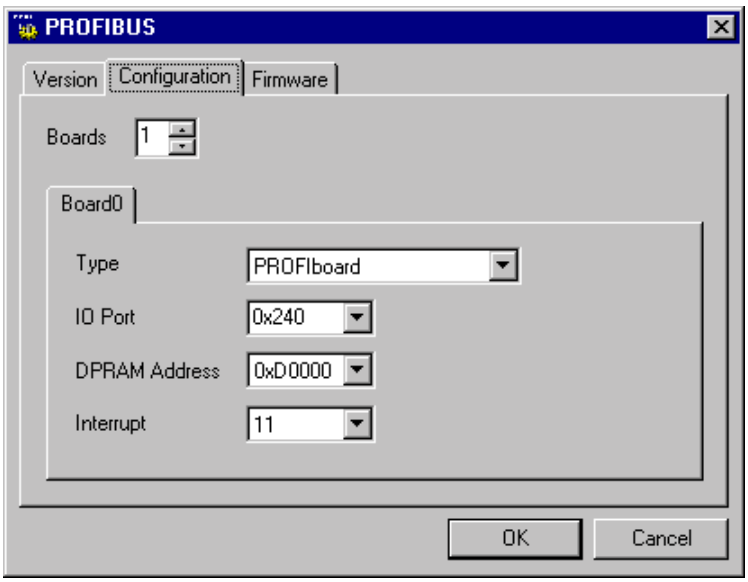
Device drivers for the Profibus Boards

When installing Open Control and with it the Profibus configurator ProfiControl device drivers are installed for the Profibus DP **master** board. This device drive can be configured by selecting the PROFIBUS icon found in the Control Panel.



NOTE: Do not modify any setting for this driver unless you really know what you are doing. Erroneous settings may cause malfunction. If you still choose to make modifications here make ABSOLUTELY SURE that you do not include the slave board (used for the communication with Automation PC) in the count of boards. I.e. the value specified in the field **Boards** below should ONLY state the number boards to be used as Profibus DP masters. The reason for this is that the device driver will automatically download DP master firmware to all boards specified here. To make a board behave as a DP slave it must be configured with special firmware. This must be done manually using special software. Please contact Atlas Copco Assembly Systems for instructions on how to do this.



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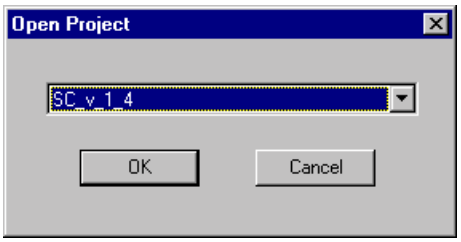
Configuration of the Station Controller

The Station Controller application program must be adopted to the current installation of the *mini*MACS system before it will work properly.

To do this you need to have access to an OpenControl development environment. You get access to the development environment by using a special “dongle”.

Before the configuration can start you must start OpenControl and select the Station Controller as the current project. Do the following:

- Start OpenControl
- Select the menu item **File/Open Project…** This will display a dialogue



in which you select the latest version of the Station Controller application, e.g. SC_v_1_4, using the drop down combo box.

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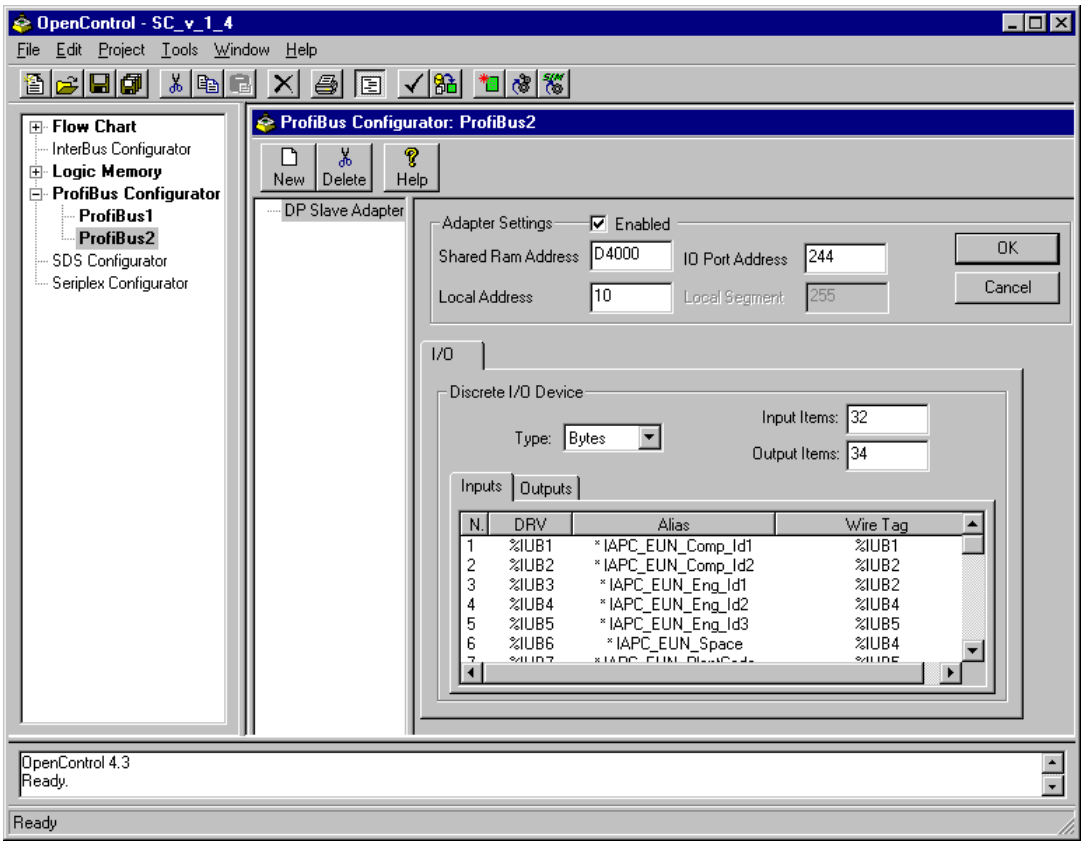
Setting the Profibus slave address

Which slave address the Station Controller should have on the Automation PC's Profibus net varies from site to site. To change it do the following:



- In the left panel: - select the item **Profibus Configurator/Profibus2**
- In the right panel: - set the correct slave address in the field **Local Address**
- Be sure to press the button **OK**
- Select the menu item **File/Save**

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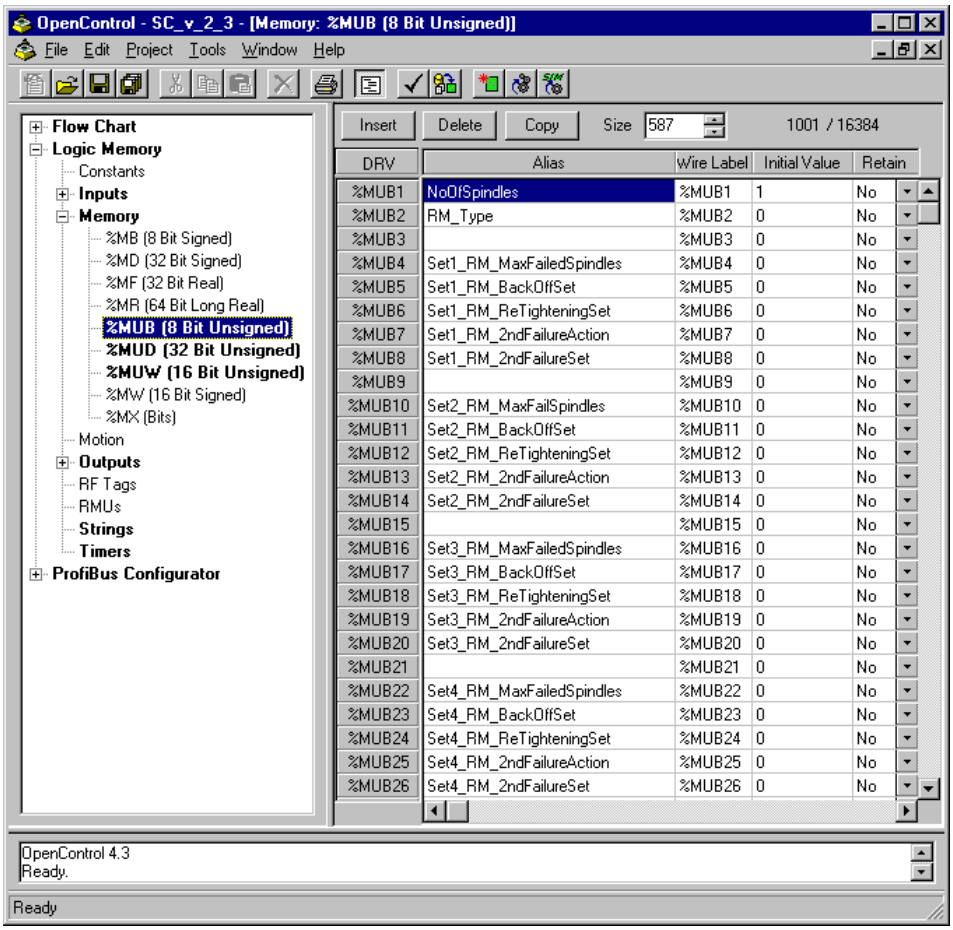
Setting the OpenControl parameters

To use the Station Controller together with a particular tightening set-up, defined using WinQCM-E, a number of parameter must be configured, see e.g. 4.3 Basic functionality and 4.4 Reject management.

To do that, do the following:



- In the left panel: - select the item **Logic Memory/Memory/%MUB (8 Bit Unsigned)**
- In the right panel: - Locate the parameters name in column **Alias** and set the correct value in column **Initial Value:**
- Select the menu item **File/Save**

Recompilation

After giving the parameters above appropriate values the application must be recompiled.

Note: If you do not have a “dongle” that enables the development environment you should not recompile the application. It would create a runtime version that only executes for a period of 30 minutes.

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Issue the following commands from inside OpenControl:

- Project/Build Runtime
- Project/Activate Project

Then close OpenControl and start The OpenControl Monitor.

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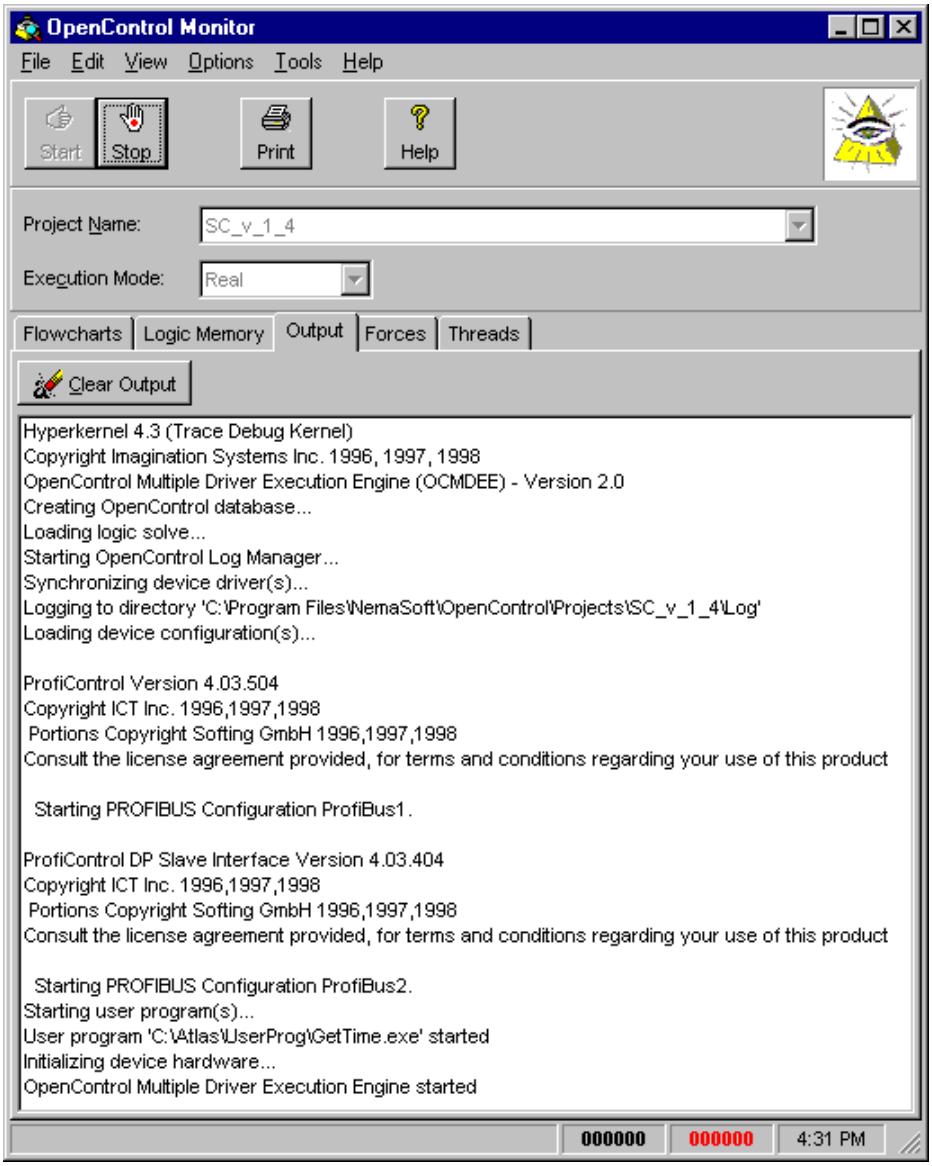
The OpenControl Monitor

Configuring the OpenControl Monitor

The OpenControl Monitor needs to be set-up with which default project it should execute when started. To do this, start the OpenControl Monitor:



- Select the latest version of the Station Controller application, e.g. SC_v_2_2, using the drop down combo box labelled **Project Name**.
- Ensure that the Execution Mode is set to Real
- Press the Start button

Auto start of the OpenControl Monitor

By providing an argument to the OpenControl monitor when started it can automatically launch the Station Controller application started.

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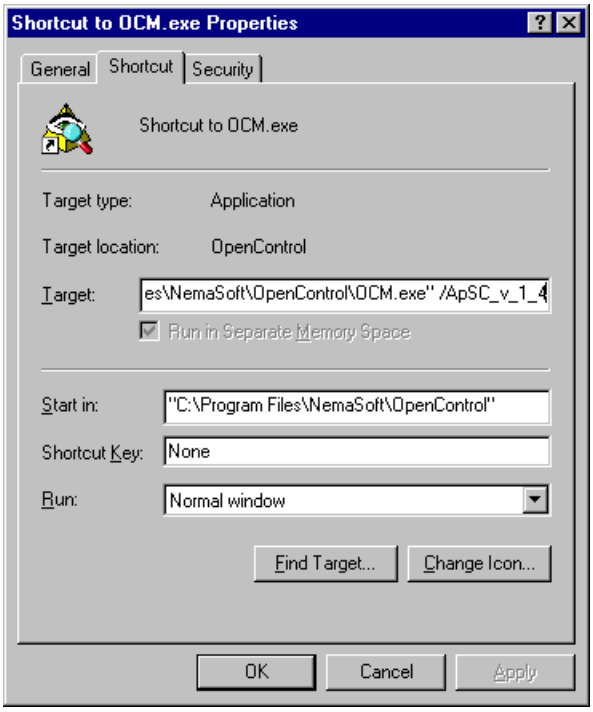
By placing a short cut to the OpenControl Monitor in the Autostart group the PC can then be configured to automatically start the Station Controller whenever the PC is started.

To do that do the following:

- Create a shortcut to the OpenControl monitor ('OCM.EXE') in **C:\WINNT\Profiles\All Users\Start Menu\Programs\Autostart**.

  The file OCM.EXE is normally found in the directory **C:\Program Files\Nemasoft\OpenControl**.
- Edit the properties of the shortcut by adding '**/ApSC_v_1_4**' to the field labelled **Target**.



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Appendix

Appendix 1: SPC Calculations

Calculations for subgroups

Data in a subgroup is calculated as:

where n = size of subgroup

Calculations

When the specified number of subgroups to use for calculations have been collected, the SPC function will start calculations to determine the statistical stability. This will be repeated every time a new subgroup is ready.

Calculations are performed in following steps: (m = number of subgroups)

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Calculation of Average of Average values:

Calculation of Average of Range or Standard deviation:

Calculation of Control levels:

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Calculation of the process capabilities Cp and Cpk:

where for a normal distribution su = sl = 3

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SPC constants

The table below gives the constants to use in the mathematical formulas.

Subgroup Size	Divisors for Estimate of Standard Dev.		Factors for Control Limits					
n	d2	c4	A2	D3	D4	A3	B3	B4
2	1.13	0.798	1.88	-	3.27	2.66	-	3.27
3	1.69	0.886	1.02	-	2.57	1.95	-	2.57
4	2.06	0.921	0.73	-	2.28	1.63	-	2.27
5	2.33	0.940	0.58	-	2.11	1.43	-	2.09
6	2.53	0.952	0.48	-	2.00	1.29	0.03	1.97
7	2.70	0.959	0.42	0.08	1.92	1.18	0.12	1.88
8	2.85	0.965	0.37	0.14	1.86	1.10	0.19	1.82
9	2.97	0.969	0.34	0.18	1.82	1.03	0.24	1.76
10	3.08	0.973	0.31	0.22	1.78	0.98	0.28	1.72
11	3.17	0.975	0.29	0.26	1.74	0.93	0.32	1.68
12	3.26	0.978	0.27	0.28	1.72	0.89	0.35	1.65
13	3.34	0.979	0.25	0.31	1.69	0.85	0.38	1.62
14	3.41	0.981	0.24	0.33	1.67	0.82	0.41	1.59
15	3.47	0.982	0.22	0.35	1.65	0.79	0.43	1.57
16	3.53	0.984	0.21	0.36	1.63	0.76	0.45	1.55
17	3.59	0.985	0.20	0.38	1.62	0.74	0.47	1.53
18	3.64	0.985	0.19	0.39	1.61	0.72	0.48	1.52
19	3.69	0.986	0.19	0.40	1.60	0.69	0.50	1.50
20	3.74	0.987	0.18	0.42	1.59	0.68	0.51	1.49
21	3.78	0.988	0.17	0.42	1.58	0.66	0.52	1.48
22	3.82	0.988	0.17	0.43	1.57	0.65	0.53	1.47
23	3.86	0.989	0.16	0.44	1.56	0.63	0.55	1.46
24	3.90	0.989	0.16	0.45	1.55	0.62	0.56	1.45
25	3.93	0.990	0.15	0.46	1.54	0.61	0.57	1.44

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Appendix 2: Interface to the Automation PC

Inputs

The interface to the overriding Automation PC consists of the following input signals (items printed in italic on grey background are optional and may be used if so wanted):

Byte	Description	Comment
0	EUN, Comp ID	ASCII {Numeric}
1	EUN, Comp ID	ASCII {Numeric}
2	EUN, Engine ID	ASCII {Alpha-Numeric}
3	EUN, Engine ID	ASCII {Alpha-Numeric}
4	EUN, Engine ID	ASCII {Alpha-Numeric}
5	EUN	ASCII {Space}
6	EUN, Plant code	ASCII {Numeric}
7	EUN, Build year	ASCII {Numeric}
8	EUN, Build year	ASCII {Numeric}
9	EUN, Julian day	ASCII {Numeric}
10	EUN, Julian day	ASCII {Numeric}
11	EUN, Julian day	ASCII {Numeric}
12	EUN, Daily seq. No.	ASCII {Numeric}
13	EUN, Daily seq. No.	ASCII {Numeric}
14	EUN, Daily seq. No.	ASCII {Numeric}
15	EUN, Daily seq. No.	ASCII {Numeric}
16	Spare	For Potential 4 Byte Build Year*
17	Spare	For Potential 4 Byte Build Year*
18	Station Byte	Binary - See description below
19	Spindle Bypass (1-8)	Binary - See description below
20	Spindle Bypass (9-16)	Binary - See description below
21	Spindle Bypass (17-24)	Binary - See description below
22	Spindle Bypass (25-32)	Binary - See description below
23 – 31	Spare	Future Use

Station Byte Description (Byte 18):

Bit	Dec.	Description	Comment
0	1	Start	Starts the station i.e. all spindles
1	2	Stop	Stops the station i.e. Machine stop to all spindles
2	4	Parameter Bit 0	Tightening set binary bit 0 (value 1)
3	8	Parameter Bit 1	Tightening set binary bit 1 (value 2)

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4	16	Parameter Bit 2	Tightening set binary bit 2 (value 4)
5	32	Parameter Bit 3	Tightening set binary bit 3 (value 8)
6	*64*	*Link alive*	*The use of this bit is optional. If the parameter "SuperviseAPCLink" is set to one (1) the Station Controller uses this signal to supervise the connection to the Automation PC. If found 0 (zero) the station will be stopped.*
7	128	Reset	On pos. edge station & all spindles will be reset

Spindle Bypass (Byte 19 - 22):

Bit	Dec.	Description	Comment
0	1	Inhibit Spindle 1	If set to 1 spindle will be bypassed next cycle
1	2	Inhibit Spindle 2	If set to 1 spindle will be bypassed next cycle
2	4	Inhibit Spindle 3	If set to 1 spindle will be bypassed next cycle
3	8	Inhibit Spindle 4	If set to 1 spindle will be bypassed next cycle
4	16	Inhibit Spindle 5	If set to 1 spindle will be bypassed next cycle
5	32	Inhibit Spindle 6	If set to 1 spindle will be bypassed next cycle
6	64	Inhibit Spindle 7	If set to 1 spindle will be bypassed next cycle
7	128	Inhibit Spindle 8	If set to 1 spindle will be bypassed next cycle

Outputs

The interface to the overriding Automation PC consists of the following output signals (items printed in italic on grey background are optional and may be used if so wanted):

Byte	Description	Comment
0	Station byte 1	Binary - See description below
1	Station byte 2	Binary - See description below
2	Spindle 1 byte	Binary - See description below
3	Spindle 2 byte	Binary - See description below
…		Binary - See description below
33	Spindle 32 byte	Binary - See description below
34	*Station byte 3*	*The use of this byte is optional. Binary - See description below*
35	*Station byte 4*	*The use of this byte is optional. Binary - See description below*

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Station Byte 1:

Bit	Dec.	Description	Comment
0	1	OK	All spindles in the station have ended the cycle correctly
1	2	NOK	All spindles in the station have not ended the cycle correctly
2	4	Running	Station is busy running the tightening cycle (including RM actions)
3	8	RM back-off started	The first RM action started. Bit is cleared of a new station start
4	16	RM re-tightening started	The second RM action started. Bit is cleared of a new station start
5	32	Communication error	Communication with FBU, or between FBU and spindles, failed
6	64	Parameter-set failure	Different set numbers returned from the active spindles
7	128	E-stop	DC Bus low from all active spindles

Station Byte 2:

Bit	Dec.	Description	Comment
0	1	Parameter bit0	Confirm tightening set (binary 1)
1	2	Parameter bit1	Confirm tightening set (binary 2)
2	4	Parameter bit2	Confirm tightening set (binary 4)
3	8	Parameter bit3	Confirm tightening set (binary 8)
4	16	Spare	
5	32	Spare	
6	64	Spare	
7	128	Spare	

Spindle Byte Description (Bytes 2 - 33):

Bit	Dec.	Description	Comment
0	1	Cycle NOK	1 = NOK
1	2	Spindle Bypassed	1 = Servo was bypassed
2	4	Torque NOK	1 = NOK
3	8	Angle NOK	1 = NOK
4	16	Controller OK/Ready	1 = OK/Ready
5	32	Time out Error	1 = Time out exceeded
6	64	Transducer measure error	1 = Calibration, Offset, or Overflow error
7	128	DC-Bus low	1 = DC-Bus low on the servo

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Station Byte 3 (optional):

Bit	Dec.	Description	Comment
0	1	Stopped	This use of this bit is optional. Is set high if the Station Controller is stopped due to that the Automation PC issued a Stop order.
1	2	Cycle Start Error	This use of this bit is optional. Is set if all spindles did not report that they are running within the time defined by the "CycleStartTimer "(1000 ms).
2	4	FBU comm. Error	This use of this bit is optional. Is set high if the Station Controller have lost the contact with the FBU.
3	8	WinQCM overrun	This use of this bit is optional. Is set high if the WinQCM did not finish reading cycle data within the time defined by the "WinQCMTimer" (3000 ms).
4	16	Spindle Comm. Error	This use of this bit is optional. Is set high if the FBU loose contact with one or more spindles.
5	32	NT crashed	This use of this bit is optional. Is set high if NT crashes.
6	64	Ready for Start	This use of this bit is optional. Is set high when the Station Controller accepts a new start order. After that the signal Running goes low a new start is not accepted until the WinQCM has finished.
7	128	APC comm. Error	This use of this bit is optional. Is set high when the Station Controller has lost contact with the Automation PC. Only active if supervision is enabled using one of the parameters StopSignalIsNegated or SuperviseAPCLink

Station Byte 4 (optional):

Bit	Dec.	Description	Comment
0	1	Parameter Error	This use of this bit is optional. It is set high if the parameter NoOfSpindles is set higher than 32 or if parameter RM_NoOfGroups is set higher than 16.
1	2	Spare	
2	4	Spare	
3	8	Spare	
4	16	Spare	
5	32	Spare	
6	64	Spare	
7	128	Spare	

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Appendix 3: FBU Profibus interface

The Station Controller controls the tightening system over a Profibus DP interface. The control input data is sent from the Station Controller over the Profibus DP interface to the FBU, where the signals are unpacked and distributed to all servo drive units over the Lan1 bus. Qualitative output data or cycle status (i.e. Running, OK, NOK...) from all drive units are continuously retrieved by the FBU and sent to the Station Controller over the Profibus DP interface. For a more detailed description of the Profibus DP interface, see [Ref.05].

Control Input Data

The Profibus output buffer of the Station Controller and the Profibus input buffer of the FBU each holds 41 bytes of data. As soon as any value in the Station Controller buffer changes, the complete 41 bytes are sent over the Profibus to update the FBU buffer. The buffers hold the following data:

Byte	Description	Comment
0	EUN Byte 1	Character 1 (first) of the EUN code
1	EUN, Comp ID	Character 2 of the EUN code
2	EUN, Engine ID	Character 3 of the EUN code
3	EUN, Engine ID	Character 4 of the EUN code
4	EUN, Engine ID	Character 5 of the EUN code
5	EUN	Character 6 of the EUN code
6	EUN, Plant code	Character 7 of the EUN code
7	EUN, Build year	Character 8 of the EUN code
8	EUN, Build year	Character 9 of the EUN code
9	EUN, Julian day	Character 10 of the EUN code
10	EUN, Julian day	Character 11 of the EUN code
11	EUN, Julian day	Character 12 of the EUN code
12	EUN, Daily seq. No.	Character 13 of the EUN code
13	EUN, Daily seq. No.	Character 14 of the EUN code
14	EUN, Daily seq. No.	Character 15 of the EUN code
15	EUN, Daily seq. No.	Character 16 (last) of the EUN code
16 –24	Not used	
25	Start Time, byte 0	See description below.
26	Start Time, byte 1	See description below.
27	Start Time, byte 2	See description below.
28	Start Time, byte 3	See description below.
29	Start Time, byte 4	See description below.
30	Start Time, byte 5	See description below.
31	Start Time, byte 6	See description below.

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32	Start Time, byte 7	See description below.
33	No. of spindles	Number of spindles in this station.
34	Station Control, byte 0	See description below.
35	Station Control, byte 1	See description below.
36	Inhibit mask, byte 0	Bypass spindle 1 to 8; bit 0 <=> spindle 1, bit 1 <=> spindle 2, etc.
37	Inhibit mask, byte 1	Bypass spindle 9 to 16; bit 0 <=> spindle 9, bit 1 <=> spindle 10, etc.
38	Inhibit mask, byte 2	Bypass spindle 17 to 24; bit 0 <=> spindle 17, bit 1 <=> spindle 18, etc.
39	Inhibit mask, byte 3	Bypass spindle 25 to 32; bit 0 <=> spindle 25, bit 1 <=> spindle 26, etc.
40	Inhibit mask, byte 4	Bypass spindle 33 to 40; bit 0 <=> spindle 33, bit 1 <=> spindle 34, etc.

The EUN code and Start Time data are sent to all servo drive units. This is only information included for stamping report and trace data etc. The Inhibit mask, Station Control bytes and No. of Spindles data are combined to an 8 bytes control word, which is also sent to all drive units. In each servo drive unit this information is first unpacked and then the Station Control bytes are combined with the bit in the Inhibit mask that corresponds to the drive units node number. The modified Station Control bytes are then used as input to the local sequence handler in the servo drive unit.

The Start Time is not used internally by the FBU or the servos but it is reported to the WinQCM on request. The Start Time is dived in two parts namely:

- The number of seconds elapsed since midnight Jan 1970. Handled as 32 bit integer using the following bytes

  Start Time, byte 1 MSB
  Start Time, byte 0
  Start Time, byte 3
  Start Time, byte 2 LSB

- The number of milliseconds elapsed since midnight the current day. Handled as 32 bit integer using the following bytes

  Start Time, byte 5 MSB
  Start Time, byte 4
  Start Time, byte 7
  Start Time, byte 6 LSB

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The control data included in Station byte (no.5 above) are listed below:

Byte	Bit	Dec	Signal Name	Description
34	0	1	Machine Stop_N	Logic zero will stop the tightening step in progress and put the servo in status NOK. No other operations are involved. Note: Not to be used with emergency stop.
	1	2	Controller ON	Set the input to logic one to enable the servo drive to run a parameter set. When “Controller ON” is set to logic zero the panel alarm indicators are cleared and the servo drive unit is reset from any error condition except breakdown in the resolver connection. In this case you must power down the servo drive, correct the error and power up again to reset the error signal. Please note! The output signal “Controller OK” must indicate the servo drive running properly (relay contacts closed at connector K7B:35-36) at the time “Controller On” is set to logic one. The internal computer reads the transition from one logic level to the other!
	2	4	Cycle Stop	Logic one will stop the tightening step in progress and put the servo drive in status OK, if the control mode for the step is of type “END”. If the control mode for the step is of type “Con” (for continue), the next step program will be started. No other operations are involved. Designed with for instance positioning tasks in mind. A limit switch can be used for the “Cycle Stop” input.
	3	8	Start	Set the input to logic one to start a tightening cycle beginning with the step program selected by the address on “Select 1/-2/-4/-8/-16/-32” and ending with the step program containing the control mode “END”. The input signal “Controller ON” has to be set to logic one(green LED “Rdy” is lit), before the “Start” signal is activated.
	4	16	Step Sync. IN	Logic one will inhibit a start of a tightening step. Set the input to logic zero to enable start. Use the input in conjunction with the “Step Sync. OUT” output signal from the same servo drive or a combination of several drives.
	5	32	Step Mode	Set the input to logic zero to have a complete cycle (with several steps) run for each start signal (normal mode). If you want the servo drive to run only one step at a time for each start signal, set this input to logic one. Mainly used in test and start-up situations.
	6	64	Inhibit	Logic one will inhibit a start of a tightening cycle. Set the input to logic zero to enable start.
	7	128	Not used	-
35	0	1	Set Select 0	1st bit (with weight 1) in the address word for selecting a program set.
	1	2	Set Select 1	2nd bit (with weight 2) in the address word for selecting a program set.
	2	4	Set Select 2	3rd bit (with weight 4) in the address word for selecting a program set.
	3	8	Set Select 3	4th bit (with weight 8) in the address word for selecting a program set.
	4	16	Set Select 4	5th bit (with weight 16) in the address word for selecting a program set.

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	5	32	Set Select 5	6th bit (with weight 32) in the address word for selecting a program set.
	6	64	Not used	-
	7	128	Not used	-

Qualitative Output Data

Each servo drive unit continuously updates an output buffer of 4 bytes with its cycle status. The FBU retrieves these data once every 100ms from all the drive units over the Lan1 bus, and combines all data in its Profibus output buffer. Since up to 40 drive units can be connected in the same station, the FBU output buffer can be up to 160 bytes. As soon as any value in this FBU buffer changes, the complete 160 bytes are sent over the Profibus to update the corresponding Profibus input buffer in the Station Controller. The 4 bytes of cycle status, similar for each drive unit, are as follows:

Byte	Bit	Dec	Signal Name	Description
0	0	1	Cycle OK	Cycle finished with parameters within programmed limits
	1	2	Cycle NOK	Cycle finished with parameters outside programmed limits
	2	4	Spindle inhibited	Confirming servo was inhibited
	3	8	Spindle Running	Tightening cycle running
	4	16	Controller OK	Servo drive unit ready for start
	5	32	Step Sync. OUT	Step finished, i.e. wait until all spindles ready with step (for paralleling in multiple nut runner systems)
	6	64	Not used	-
	7	128	Spindle Com. Err.	Spindle Communication Error
1	0	1	Timeout	Error Bit 0
	1	2	MinAngle	Error Bit 1
	2	4	MaxAngle	Error Bit 2
	3	8	MinTorque	Error Bit 3
	4	16	MaxTorque	Error Bit 4
	5	32	Mstop	Error Bit 5
	6	64	Not used	Error Bit 6
	7	128	Spindle error	Error bit 7
2	0	1	Set Confirm 0	Mirrors ”Set Select 0” bit above
	1	2	Set Confirm 1	Mirrors ”Set Select 1” bit above
	2	4	Set Confirm 2	Mirrors ”Set Select 2” bit above
	3	8	Set Confirm 3	Mirrors ”Set Select 3” bit above
	4	16	Calibration error	1=Calibration error
	5	32	Offset error	1=Offset error
	6	64	Overflow error	1=Overflow error
	7	128	DC bus fault	1=DC bus low
3	0	1	Step number 0	1st bit in the step number

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	1	2	Step number 1	2nd bit in the step number
	2	4	Step number 2	3rd bit in the step number
	3	8	Step number 3	4th bit in the step number
	4	16	Step number 4	5th bit in the step number
	5	32	Step number 5	6th bit in the step number
	6	64	Final torque OK	1=OK/0=NOK
	7	128	Final angle OK	1=OK/0=NOK

Appendix 4: QCM2 CAN Communication

The Station Controller uses the CAN communication interface to program drive parameters and retrieve quantitative tightening data. The communication format is CAN version 2.0, which is further detailed in [Ref.06].

The parameters that have to be programmed before the tightening station can be started up are the tightening step parameters defining the tightening process (torque-, angle- and speed limits etc.), and the spindle parameters defining the characteristics of each spindle (gear ratio, scaling, regulator parameters etc.). These parameters are programmed once when the station is being commissioned and don't have to be reprogrammed until changes are to be made to the tightening cycle or a different spindle is to be used.

The quantitative tightening data that can be retrieved by the Station Controller are of two types, reports and traces. The reports of up to ten parameters can be chosen to be retrieved after each cycle while the traces, containing a lot more data are retrieved only on an operators request.

Step Parameters

The basics of the steps are described in 2.3.3 Spindle. Each one of the 64 steps has 10 parameters numbered from 1 to 10. In the servo drive unit the parameters are stored internally in an EEPROM memory. Depending on which control mode (see 2.3.3 Spindle) that is programmed into a step, the included parameters are as follows:

Par1	Par2	Par3	Par4	Par5	Par6	Par7	Par8	Par9	Par10
Delay	-	-	-	-	-	A_max	A_min	-	Timeout
Torque	T_trig	T_max	T_min	Speed	-	A_max	A_min	Delay	Timeout
Angle	-	T_max	T_min	Speed	A_trig	A_max	A_min	Delay	Timeout
Jog	-	T_max	-	Speed	-	A_max	A_min	Delay	Timeout
DynaTork	T_trig	T_max	T_min	Speed	-	A_max	A_min	Delay	Timeout
Yield	T_trig	T_max	T_slope	Speed	A_slope	A_max	A_min	Delay	Timeout

Where:

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- T_trig [Nm/10]: Target value for torque steps. For yield steps this is the level where the reference slope is measured.
- T_max [Nm/10]: Max level for torque (alarm level).
- T_min [Nm/10]: Min level for torque (alarm level). For yield steps this is the relative trig level on the slope.
- Speed [rpm, signed]: Speed set point for all steps.s
- A_trig [degrees]: Target value for angle steps. For yield steps this is the base angle for slope calculations.s
- A_max [degrees]: Max level for angle (alarm level).s
- A_min [degrees]: Min level for angle (alarm level).
- Delay [1/10sec]: Delay time for delay steps. For all other steps this is a start delay (currently the later function is not implemented in the WinQCM-E).
- Timeout [sec]: Timeout for all steps.

If a limiting parameter is set to zero, that limit will not be checked, i.e. no fault trips will occur.

Spindle Parameters

For proper operation the servo drive unit needs to know the characteristics of the spindle it is supposed to operate. The spindle characteristics are defined in 15 parameters, numbered from 1 to 15. In the servo drive unit the parameters are stored internally in an EEPROM memory. The parameters are as follows:

Param.	Signal Name	Description
Par1	Gear100	Gear Ratio x 100 (signed to adjust for offset spindles, 1600=1:16 ratio)
Par2	MTorq100	motorKt x servomaxcurrent x 100 (265 = 15A servo and QMR42 spindle)
Par3	Torqueunit	1 = Nm, 2 = Flbs
Par4	Torquescale	Nominal torque for transducer (500 = 50Nm sensor)
Par5	Sensorgain	Gain setting for transducer input [0,4]
Par6	FilterK	Filter constant for transducer input [0,3]
Par7	TraceT	Sample time for traces (default 1ms) [0,10]
Par8	Pgain	Proportional gain for controller
Par9	Igain	Integral gain for controller
Par10	Dgain	Derivative gain for controller
Par11	NomSpeed	Nominal speed for motor [rpm]
Par12	RampTime	Ramp time to nominal speed [ms]
Par13	NrOfDecimals	Number of decimals in torque parameters
Par14	Relaymask	Function of relay
Par15	Holdmask	Position hold function
Par16	Spindletype	The selected spindle type

Report Parameters

After a set is completed a number of data will be available for retrieval by the Station Controller. The retrieval is initiated by creating a report through marking

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a step in a set with a report tag, as detailed in 2.3.3 Spindle. When a step fails a report is always created.

The report consists of 22 parameters numbered from 1 to 22. The first 10 parameter values represent the status and the result of the tightening cycle. Parameters number 11 through 22 represent the EUN code (par11-18) and the StartTime (par19-22). The EUN code and the StartTime were transferred to the drive units together with the control input data over the Profibus interface, as described in 7.3.1 Control Input Data.

Parameters 1 through 10 are as follows:

Param.	Signal Name	Description
Par1	StepNumber	The number of the reported step (can differ from the “report”-marked step when a step fails)
Par2	StepStatus	The status of the reported step (bit masked information on what went wrong, see below)
Par3	ReportTorque	The actual torque that was reached during the reported step
Par4	ReportAngle	The actual angle that was reached during the reported step
Par5	Not used	-
Par6	Not used	-
Par7	Not used	-
Par8	Not used	-
Par9	Not used	-
Par10	Not used	-

Parameter 2 (StepStatus) holds the following information:

Bit	Signal Name	Description
0	Timeout	Timeout exceeded
1	Minangle	Min angle not reached
2	Maxangle	Max angle exceeded
3	Mintorque	Min torque not reached
4	Maxtorque	Max torque exceeded
5	Mstop	Machine stopped
6	Not used	-
7	Not used	-
8	Calibration error	Torque measurement out of calibration (checked when starting a set)
9	Offset error	Torque measurement offset too big (checked when starting a set)
10	Overflow error	N/A
11	Not used	-

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12	Not used	-
13	Not used	-
14	Not used	-
15	Not used	-

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Trace Parameters

Each tightening set is recorded into a trace buffer. The angle and torque values are sampled with 1kHz (parameter 7 “TraceT” of the spindle parameters in 7.4.2 Spindle Parameters sets the sampling rate) and pushed onto the buffer. Each buffer has 2047 positions and if more samples are pushed, the oldest will be lost.

The system supports 20 trace buffers. Buffer 1 through 10 holds the latest OK/ NOK cycle recordings, while trace buffers 11 through 20 holds the latest NOK cycle recordings.

When a new cycle starts the oldest trace buffer will be overwritten and called number 1. Trace buffer number 2 then holds the previous cycle recording.

If a tightening cycle fails, trace number 1 (which have just been recorded) will be copied to buffer 11.

The header of each buffer will contain the following data:

- Nr. of samples (max 2047)
- TraceT (sample rate)
- SpindleNo (1-40)
- Stepstatus
- EUN code
- StartTime

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References

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2.	CPU2 for 'Enhanced *mini*MACS' – Requirement Specification	ASY QSW99036/GF, 990122
3.	QCM2 User's Manual 4.0	ACC 9032 0019 01a, Feb 10th 1999
4.	FBU User's Manual 1.0	ACC 9032 0016 01a, Dec 9th 1997
5.	Profibus Specification	ASY QSW99032/OM, July 7 1999
6.	CAN Specification	ASY QSW99114/OM, Sep 17 1999
7.	Profibus specification APC –FPC	ASY QSW99031/OM, July 7 1999
8.	OpenControl User Guide – Version 4.3	NemaSoft

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Glossary of Terms

BNF

Backus-Naur Form. A notation commonly used for describing context free grammars.

CAN

Controller Area Network

Con

Short for Continue

Cp

Process capability

Cpk

Process capability including spread

CPU

Central Processing Unit

DC-BUS

Directed Current Bus

DGAIN

Proportional gain for controller

ECT

Edit Compile Test. Development environment for the DMC servos

EOL

End Of Line. An ASCII character marking the end of a line of text.

E-Stop

Emergency stop

EUN

Engine Unit Number

FBU

Field Bus Unit

ft lb

Foot Pound (libra)

GUI

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Graphical User Interface

I/O

Input / Output

IGAIN

Integral gain for controller

INC

Increment

LAN

Local Area Network

LTL

Lower Tolerance Limit

MMS

Manufacturing Message Standard

PC

Personal Computer

PGAIN

Proportional gain for controller

PLC

Programmable Logic Controller

Rdy

Short for Ready

RM

Reject Management

sl

Standard deviation lower limit

SPC

Statistic Process Control

su

Standard deviation upper limit

TC

Torque slope reference. The torque value used as reference value for when executing a Yield step

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TDA

Trend Deviation Analysis

UPS

Un-interruptible Power Supply

UTL

Upper Tolerance Limit

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